PERSPECTIVES ON EQUITABLE WATER RESOURCE ALLOCATION FROM A DECISION EXPERIMENT

A Thesis Submitted to the College of Graduate Studies and Research

in Partial Fulfillment of the Requirements

for the Degree of Master of Public Policy

in the Johnson-Shoyama Graduate School of Public Policy

University of Saskatchewan

Saskatoon

By

Jamie Ross

PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a Postgraduate degree from the University of Saskatchewan, I agree that the libraries of this University may make it freely available for inspection. I further agree that permission for copying of this thesis in any manner, in whole or in part, for scholarly purposes may be granted by the professor or professors who supervised my thesis work or, in their absence, by the Head of the Department or the Dean of the College in which my thesis work was done. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of Saskatchewan in any scholarly use which may be made of any material in my thesis. Requests for permission to copy or to make other uses of materials in this thesis, in whole, or part, should be addressed to:

Head, Johnson-Shoyama Graduate School of Public Policy
University of Saskatchewan
Diefenbaker Building, 101 Diefenbaker Place
Saskatoon, Saskatchewan
Canada, S7N 5B8

DISCLAIMER

Reference in this dissertation to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement, recommendation, or favoring by the University of Saskatchewan. The views and opinions of the author expressed herein do not state or reflect those of the University of Saskatchewan, and shall not be used for advertising or product endorsement purposes.

ABSTRACT

Awareness of the importance of policy regarding the equitable distribution of global water resources is increasing. The purpose of this research study was to investigate the effects of allocation rules and drought conditions on allocation decisions through a decision experiment based on an idealized river basin that simulated conditions in the Saskatchewan River Basin. Participants took on the roles of water managers responsible for allocating water resources to four competing sectors in Alberta, Saskatchewan, and Manitoba. Three variations of allocation rules were tested: (a) status-quo allocation rules mimicking the current governance structure involving prearranged allocation rules across regions, (b) no predetermined rules, and (c) no predetermined rules but communication among participants. Each allocation rule was tested under two potential water levels: (a) drier-than-average conditions today reflecting 81% of historical flows, and (b) severe drought conditions with a 45% reduction from today's flows. Results showed that policy had a significant effect on how participants allocated water resources, indicating that the absence of defined minimal flow rules and the lack of communication among riparian users resulted in less equitable distribution of water, with negative ramifications for downstream users. Additionally, results showed that drought-induced water scarcity significantly affected allocation patterns, with participants choosing to protect municipal water use at the expense of industry and agriculture in the face of water shortage conditions. For decision makers and water stakeholders in the Saskatchewan River Basin, these findings provide insight into the effectiveness of the 1969 Master Agreement on Apportionment to ensure the equitable distribution of water through defined minimum flows and the problem of fragmented governance, which prevents effective communication between upstream and downstream users. The findings also highlighted the importance of having a formal rule structure to oversee allocations or ongoing communication processes to facilitate problem solving in preparation for drought conditions.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Perspectives on Equitable Water Resource Allocation from a Decision Experiment

1. Introduction

The management of freshwater resources across the world faces numerous growing challenges, including water scarcity, conflicts over water use and access, and ecosystem degradation (Böhmelt et al., 2014; Earle, Jagerskog, & Ojendal, 2010; McCaffrey, 2007; Vörösmarty et al., 2010). The Organization for Economic Cooperation and Development (OECD) estimates that, globally, 2.8 billion people live in areas experiencing water stress, a number estimated to rise to 3.9 billion by 2030 (OECD, 2009). The scale of these issues reflects ineffective past management practices and signals the need for a fundamental change in water management. Previous actions to mitigate these problems have been more incremental than innovative, in part because of inherent conservatism in the water management community (Lach, Ingram, & Rayner, 2005).

This paper examines the water management policies within the Saskatchewan River Basin and outlines potential issues for future water security within the provinces of Alberta, Saskatchewan, and Manitoba. In creating an interactive decision experiment, we sought to test if alternative policy options would prompt different priorities and methods of adapting to extreme water shortages.

1.1 The Saskatchewan River Basin

The Saskatchewan River Basin is one of the world's larger river basins, covering 336,000 km^2. Originating in the Canadian Rocky Mountains, snowmelt and glacial runoff flow eastward via two main tributaries (the North Saskatchewan and South Saskatchewan rivers) through the Prairie Provinces of Alberta, Saskatchewan, and Manitoba, with the river basin discharging the majority of its water into Lake Winnipeg (Gober & Wheater, 2014; Partners for the Saskatchewan River Basin, 2009a; Fig. 1). The Saskatchewan River Basin lies in a dry prairie eco-zone, which produces short, warm, dry summers and long, cold, and relatively dry winters. This zone is susceptible to large weather and climate extremes, from severe droughts (most recently seen in 2001–2002), to severe floods such as those in Saskatchewan in 2011 and Alberta in 2013 (Gober & Wheater, 2014; Partners for the Saskatchewan River Basin, 2009a).

Fig.1. Saskatchewan River Basin (Partners for the Saskatchewan River Basin, 2015).

Environmental change has begun to alter the natural systems that support life and economic activity in the prairies (Wheater & Gober, 2013). A warming climate is altering the runoff flows in the Rocky Mountains, affecting the timing and volume of seasonal flows (Comeau, Pietroniro, & Demuth, 2009; Demuth & Pietroniro, 2003; Marshall et al., 2011; Moore et al., 2009). Additionally, a changing climate raises concerns for new extreme conditions across the Prairie Provinces, such as droughts and floods (Bonsal, Aider, Gachon, & Lapp, 2013). One concern has been the devastating drought conditions previously seen in the 20th century—during the Dust Bowl years of the 1930s (Gober & Wheater, 2014; "Great Depression," 2015). However, these droughts were relatively mild compared to pre-settlement years: paleo-records show evidence of extreme, prolonged low-flow and drought conditions in the region (Bonsal et al., 2013; Case & Macdonald, 2003).

1.2 Current Governance

The Prairie Provinces' governance structure derives from two streams of water law: riparian law and allocation licensing. In 1870, the Prairie Provinces adopted riparian law, which is based on the principle of equitable use. The principle of equitable use, a defining feature of modern water governance, is entrenched in almost all international, regional, and basin-level agreements and promotes the fair and sustainable use of water resources among riparian users. The principle dictates that the reasonable sharing of water does not entitle equal sharing; instead, it allows the concerned riparian bodies to interpret what constitutes reasonable sharing to meet various needs and interests (Versteeg, 2007). The 1969 Master Agreement on Apportionment, signed in 1969, dictates provincial allocations across Alberta, Saskatchewan, and Manitoba (Partners for the Saskatchewan River Basin, 2009b). This agreement which uses the principle of equitable utilization, derived from historic precedents, states that Alberta may use no more than half of the natural flow arising in the province and must allow the remainder to pass into Saskatchewan. Saskatchewan, then, must use no more than half of the water that flows through the province, and allow the remainder to flow to Manitoba (Partners for the Saskatchewan River Basin, 2009b).

The Master Agreement on Apportionment solidifies the principle of equitable utilization, defining what the provinces view as equitable while allowing each province to use its water as long as the agreed-upon volumes cross the provincial borders (McCaffrey, 2007; Partners for the Saskatchewan River Basin, 2009b). Within the individual provinces, water allocation is dictated by water licenses granted by the specified licensing body within each province. The system relies on the clear establishment of priority, where junior license holders must give up their water rights to ensure that senior license holders continue to receive their allocated amounts during shortages. The Province of Alberta specifies the priority of water licenses. However, since Saskatchewan's implementation of the Water Corporation Act in 1984, the license priorities of that province have been less clear. Prior to 1984, water licenses had been prioritized by types of water use, but those provisions were not included in the current legislation (Hurlbert, 2006). Unclear prioritization of water licenses may result in conflicts in Saskatchewan during times of water stress, ultimately resulting in significant negative effects across the basin (Hurlbert, 2009; McCaffrey, 2007). Although conflict resolution legislation exists, Hurlbert (2009) argues that the process is time-consuming and inefficient and does not necessarily resolve the original problems that created the conflict.

In addition to the Master Agreement and the licensing systems within each province, each province has multiple governing agencies with varying mandates and responsibilities for the allocation, management, and protection of provincial water resources. This shared responsibility has created a complex web of provincial water management. The decentralized and fragmented governance structure creates uncertainty about what actions would be taken across the basin in times of severe water shortages.

2. Problem Statement

Specific issues concerning future water allocation arise from the ambiguity associated with the current governance structure. First, questions persist regarding the ability of the 1969 Master Agreement on Apportionment to continue to ensure the equitable use of water between the Prairie Provinces under increasing demand and changing climatic conditions. In particular, the period used to determine water apportionment for the agreement, 1912–1967, had an average mean annual flow higher than the 20th-century mean (Case & Macdonald, 2003).

Second, concerns about water management persist within each province under existing licensing and allocation systems. These systems do not accommodate flow fluctuations and provide little adaptive capacity during times of basin-wide stress (Hurlbert, 2009; Hurlbert, Corkal, & Diaz, 2009). The drought in Alberta from 2001 to 2002 showed that, at the local level, some senior license holders were willing to share their allocations with junior license holders to sustain the local region's economy and social equity (Gober & Wheater, 2014). Although this localized resilience displays the adaptive capabilities of a small number of license holders during a single-year drought, uncertainty remains regarding how water license holders throughout the basin would prioritize and allocate water over multiple years of water stress (Gober & Wheater, 2014).

Third, the fragmented water allocation governance structure throughout the Prairie Provinces raises concerns about how water actually will be allocated in times of shortage. Though it allows each province to be independent in its water management, this fragmentation may impede timely adaptation due to the bureaucratic processes of the individual governing bodies. On a larger scale, this may foster a competitive relationship among the provinces over the region's water resources (Bildhaeuser, 2010; Fishman, 2011; Hanak et al., 2011).

In the context of this uncertainty about how water would be allocated in the context of drought and shortage, the purposes of this thesis research are (a) to use an experiment with regional stakeholders to explore how drought conditions and allocation rules affect allocation decisions; (b) to identify the social processes used to formulate decisions and policies regarding the sustainable use of water resources and the protection of other riparian bodies under various drought scenarios; and (c) to determine the priorities attached to different sectors (industry, agriculture, and municipalities) in times of drought and under different policy conditions.

3. Method

In this study, we designed an interactive decision-making experiment to examine how stakeholders allocate water resources under shortage conditions and provide evidence of whether their allocation patterns change under different sets of policy rules. We chose an interactive allocation decision-making experiment over other methods such as decision-maker and stakeholder interviews, focus groups, and surveys because of its ability to stimulate learning, mimic real life, and enable participants to interact with one another and reflect on what they learned from the experience. The experiment allowed stakeholders with different interests and values to conduct water management allocations in a safe, scenario-based exercise; forced them to consider allocation trade-offs in real time; and demonstrated the value of gaining a shared understanding of water allocation planning and decision making under uncertainty in the Saskatchewan River Basin (Haug, Huitema, & Wenzler, 2011; Hu, Johnston, Hemphill, Krishnamurthy, & Vinze, 2012).

3.1. Participants

Over the course of 10 workshops throughout the Saskatchewan River Basin, we engaged 64 participants (19 from Alberta, 39 from Saskatchewan, and 6 from Manitoba) in the decision experiment. Research participants were recruited from the following watershed-based organizations: the Global Institute for Water Security, Partners for the Saskatchewan River Basin, Battle River Watershed Alliance, Beaver River Watershed Alliance, Red Deer River Watershed Alliance, South East Alberta Watershed Alliance, Association of Saskatchewan Watersheds, South Saskatchewan River Water Stewards, North Saskatchewan River Stewards, Keepers of the Saskatchewan River Delta, and Manitoba Conservation and Water Stewardship. Leaders from these organizations discussed participation with their boards of directors. If they wished to participate, they circulated an electronic poster to members. Individual participants were asked to register in advance and were emailed a consent form. The University of Saskatchewan Behavioral Research Ethics Board approved the research protocol for the decision experiment.[1]

3.2 Material and Apparatus

Jesse Langstaff of the University of Saskatchewan's Social Sciences Research Laboratories provided support for the design of the experiment. The theoretical design was formed over a great deal of discussion and trial and error regarding the choice of sectors, number of stages, severity of drought levels, and operationalization of the allocations system, with the goal of creating an experiment that was simple in its design but at the same time formed an accurate representation of the Saskatchewan River Basin.

Once we finalized the theoretical design, Langstaff translated the theoretical experiment into code and designed its execution. We ran the experiments through the University of Saskatchewan's Social Sciences Research Laboratories using the Social Sciences Research Laboratories' mobile lab. We linked desktop computers (laptops and iPads for mobile labs) via the Software Platform for Human Interaction Experiments (SoPHIE), which allowed the hardware devices to be connected in multiples of three via a web interface to form our interactive river basin (SoPHIE, 2015). In the groupings of three, each computer represented a different region based on location, including A (upstream), B (midstream), or C (downstream). We modeled the fictional river basin after the Saskatchewan River Basin and used relevant data from Alberta for Region A, Saskatchewan for Region B, and Manitoba for Region C (see Fig 2).

[1] BEH 13-386: Facilitated Empathy for Water Security in the Saskatchewan River Basin (SSHRC). Approved 2 Dec 2013.

[2] After piloting the experiment it was necessary to increase the demand for the environmental services sector to have

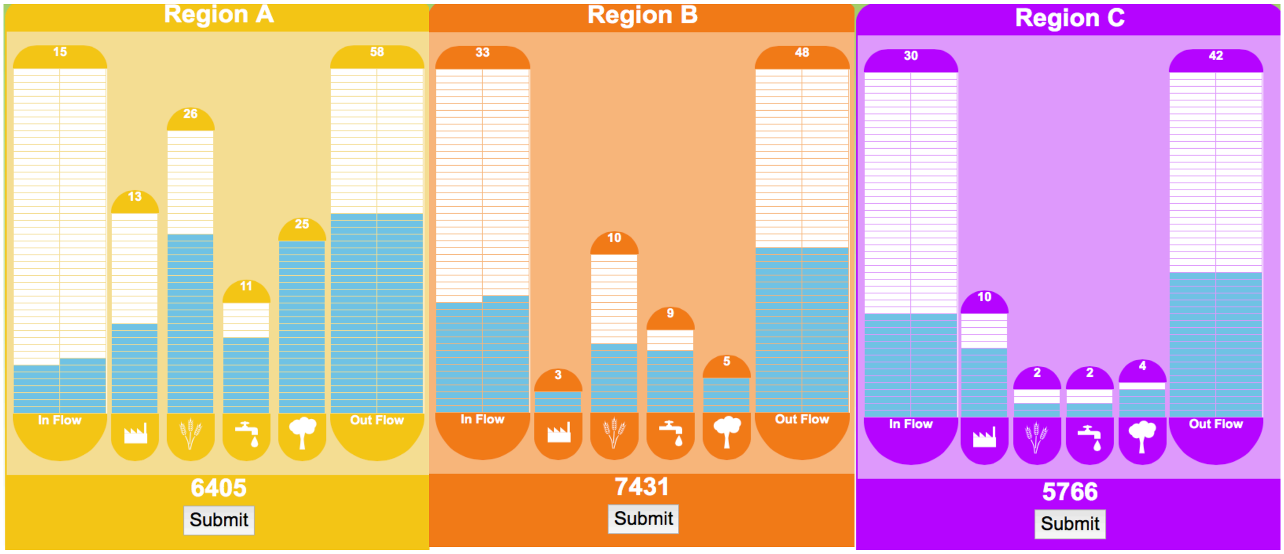


Fig. 2. Screenshot of the three regions in the interactive decision experiment.

We identified the sector demands across the basin using provincial licensing data for Alberta, Saskatchewan, and Manitoba. To simplify the experiment's design, we identified four key water-use sectors across the basin—agriculture, industry, municipal and environmental services—aggregating smaller sectors into each of the four sectors where we felt that they fit best (See Appendix A). We then created simplified, weighted water demands for each of the basin's three regions, using provincial licensing data for Alberta and Manitoba and water use records for Saskatchewan, whose values would represent the ideal 100% flow of the basin[2] (see Table 1; Dey, 2014; Government of Alberta, 2010; Kulshreshtha, Bogdan, & Nagy, 2012). The experiment also included return water flows for each sector to mimic the different levels of consumption for the experiment's four sectors. The return flow percentages for each sector were agriculture, 0%; industry, 75%; municipal, 90%; and environmental services, 100% (AMEC, 2009; Kulshreshtha, et al., 2012; Little, 2001; Martz et al., 2007; Saffran, 2005).

[2] After piloting the experiment it was necessary to increase the demand for the environmental services sector to have a large enough water demand that it would warrant larger considerations from participants when making their allocation decisions. The addition of environmental services demand increased the overall basin demand (See Appendix A).

Table 1. Sector Water Demand and Water Point Value (Per Water Unit) for the Three Regions.

	Region A		**Region B**		**Region C**	
	Demand	Points	Demand	Points	Demand	Points
Industry	29	165	3	222	15	233
Agriculture	41	3	23	19	4	44
Municipal	16	262	12	275	4	354
Environmental Services	25	-20	5	-20	5	-60

We created a corresponding economic value for each of the four sectors in our fictional basin by looking at per-capita GDP data for the Prairie Provinces to develop a summary measure of the economic benefit associated with different sets of decisions (see Table 1). We divided the economic value of each sector in each region by its respective water demand to create a weighted value for each unit of water that would be allocated to the specified sector. We rounded down the values and referred to them as "points" (a simple variable for participants to view) during the experiment, allowing us to create realistic economic impacts of water allocations. We added this variable to reduce the incidence of participants allocating evenly to the different sectors and as a means of giving them an incentivised task throughout the experiment to accumulate the most points—this was to increase their cognitive attention to the experiment and have the allocation process mimic the competitive nature of the riparian relationship (Fehr & Falk, 2002).

In addition to the four sectors to which participants could allocate, we included a fifth sector, hydropower, because of its importance to the economy of the Prairie Provinces (Canadian Hydropower Association, 2014; Hydro Quebec, 2014). However, participants could not specifically allocate to this sector. Rather, to simulate the economic benefits of having water run through hydropower stations in their regions, we awarded participants points for the amount of water they had at the start of their regions' turns. By looking at the hydropower generation capacity in combination with the average price of electricity in each province, we created a weighted score for the three regions that would best represent the economic value of hydropower, with Regions A and B receiving 20 points and Region C receiving 60 points[3] per unit at the start of their respective turns.

There was one exception to the hydropower allocations. When participants allocated to the environmental services sector, we assumed that water would not go through the region's hydropower station but rather would flow downstream unobstructed, helping to maintain environmental flows (Edenhofer et al., 2011; Hand, et al., 2012; National Academy of Sciences, 2010). Therefore, because water did not pass through the hydropower station, this resulted in a loss of points when participants allocated water units to the environmental services sector, due to not having a rigorous way of measuring the economic value of water allocated to the environment, particularly when a water quality measure was not included in the experiment.

Participants were tested under the following three policy conditions, based on the three models of global water allocation (McCaffrey, 2007). Each policy condition was tested under two potential water levels: (a) the drier-than-average conditions of today, reflecting 81% of historical flows; and (b) severe drought conditions, with a 45% reduction from today's flows.

Policy 1: the status quo. The first policy condition test mimicked the Prairie Provinces' 1969 Master Agreement on Apportionment, where regions were subject to defined minimum flows. Starting with Region A, participants were subject to defined minimum flows and could use no more than 50% of their available water units, ensuring that the other half was available for participants in Region B. Region B would in turn be subject to the same defined minimum flow conditions to ensure that 50% reached Region C.

The status quo policy condition is based on the global allocation theory of limited territorial sovereignty. The theory of limited territorial sovereignty is the most widely accepted principle of water allocation. It promotes the balanced management of water resources, whereby it does not mandate an equal allocation of water resources to all parties but instead promotes the collaboration of riparian bodies to allocate water resources fairly, depending on the water demand and needs of each riparian body—as long as those uses do not significantly harm or hinder one party's ability to meet the needs of other riparian bodies (McCaffrey, 2007).

Policy 2: no rule set. The second policy removed any rule set in the fictional basin. It is based on the principle of absolute territorial sovereignty, assuming that riparian position

[3] Region C received a higher point total than Regions A and B because Manitoba has a substantially larger generating capacity in comparison with Alberta and Saskatchewan.

determines allocation and providing upstream riparian users with a priority and monopoly over water use at the expense of downstream users (Birnie, Boyle, & Redgwell, 2009; McCaffrey, 2007).

Policy 3: the community of interest principle (shared risk). The third policy introduced the element of communication and negotiation between participants in the basin groups. The community of interest principle assumes that riparian bodies have an incentive to share the burden of management and the benefits of water resources (Birnie et al., 2009; McCaffrey, 2007). In introducing communication among participants in their basin groups, we sought to determine whether the change in experiment conditions changed how participants allocated their water resources.

3.3 Procedures

Before the experiment began, participants were divided into groups of three, with each participant randomly assigned a computer (laptop or iPad for mobile workshops) that would determine the region for which the participant would assume the role of a water manager responsible for the allocation of water resources to four competing sectors. We placed physical barriers between participants to prohibit them from seeing one another's screens, ensuring that they would not be influenced by other allocations.

The facilitator gave a brief presentation to inform participants of their roles as decision makers responsible for allocating water resources to competing sectors within their respective riparian region (e.g., upstream, midstream, or downstream) in a fictitious river basin. Participants were informed that there would be six stages within the experiment, each with varying water levels and allocation rules, and that instructions for each stage would be displayed on their screens prior to starting.

We explained the experiment mechanics, including the four sectors: water demands, return flows, hydropower, and point return from water allocated to each sector. We informed participants that the each member of the basin group with the most points at the end of the workshop would receive a prize worth around $10–$15. Before starting the experiment, participants had 5 minutes to familiarize themselves with the experiment interface in a generic region (where all the water demands were the same), and they were informed that once the experiment commenced, participants could not speak to one another unless directed to do so. We also notified participants that each region would have 2 minutes to make its allocations.

Additionally, we asked participants to write out their allocation strategies for each policy and water level scenario on a printed questionnaire that we provided.

Stage 1: Policy 1 (status quo)—Drier-than-average conditions of today. At the outset, participants' screens informed them of the Policy 1 rule set and water level scenario, describing how a lower-than-average snowpack and dry weather conditions were limiting water supply.[4] Once all participants clicked "Continue" to confirm these instructions, participants in Region A were prompted to begin their allocations. After 2 minutes, we asked participants in Region A to click "Submit" to confirm their allocations. We then prompted Region B to begin their allocations, followed by Region C. Once Region C had completed their allocations, all participants saw the next set of instructions on their screens.

Stage 2: Policy 1 (status quo)—Severe drought conditions. Still under the Policy 1 rule set (business-as-usual), participants were presented with the next set of conditions: after 4 years of drought, there was an extreme shortage of water across the river basin. Participants then allocated as they had done in Stage 1, accounting for the fact that the drought constrained the flows.

Stage 3: Policy 2 (no rule set)—Drier-than-average conditions of today. For Policy 2, the facilitator informed participants of the new policy conditions (without the Master Agreement's allocation scheme), and the allocation process proceeded as it had under Stages 1 and 2.

Stage 4: Policy 2 (no rule set)—Severe drought conditions. Still under the Policy 2 rule set (no rule set), the facilitator presented participants with extreme shortage conditions. Participants then allocated as they had done in the first three stages.

Stage 5: Policy 3 (shared risk)—Drier-than-average conditions of today. For Policy 3, instructions informed participants that each group would select representatives from Regions A, B, and C who would have 4 minutes to discuss a basin-wide allocation strategy, thus introducing the element of communication and shared learning to the experiment. We recorded each group's discussions via an audio recorder and used the information to assess qualitatively the decision process and social learning that occurred during the experiment. After the 4 minutes

[4] A narrative was chosen over showing participants the water level percentage in order to reduce participant's ability to game the experiment and maximize points.

were up, participants once again could not speak to one another and went back to their individual computers to allocate for their regions as they had done before.

Stage 6: Policy 3 (shared risk)—Severe drought conditions. Still under the Policy 3 rule set (shared risk), participants were presented with extreme shortage conditions. As in Stage 5, participants had 4 minutes to discuss a basin-wide allocation strategy. After the 4 minutes were up, participants once again could not speak to one another and went back to their individual computers to allocate for their region as they had done before (for more detail see Appendix B).

Upon completion, we announced which group had the highest point score (i.e., which basin had grossed the highest economic value from its water allocations throughout the experiment) and would therefore receive the prize. Then we debriefed the participants on the results and facilitated an open discussion to gain some insight into what the participants had decided, what had driven them to make those decisions, and which policy the participants believed most equitably distributed water resources between the regions under both water level scenarios.

4. Analytical Approach

This section provides an overview of the different variables used for analysis.

a. Region: The regions (A, B, and C) simulated the provinces of Alberta, Saskatchewan, and Manitoba (as discussed in Section 3.2).
b. Policy: The three policies in the experiment dictated the rule set for the allocation rounds (business as usual, no rules, and communication, as discussed in Section 3.2).
c. Water Availability: Water availability dictated how much water the basin (the three regions combined) would start with at the beginning of an allocation round. There were two allocation rounds for each policy rule set: one round at 81% water availability to meet the basin demand (mimicking the drier-than-average conditions of today), and another round at 45% water availability to meet basin demand (representing severe drought conditions).
d. Water Units: These represented the basin's water supply so that the participants could allocate. The analysis and results distinguished between each region's Water Units In and Water Units Out. This allowed us to see how much water each region used under the different policies and water availabilities.

A) Water Units In: The number of water units with which each region would start at the beginning of an allocation turn. For Region A, this was always the starting number of water units for the basin (either 90 or 50, depending on the water availability level). For Regions B and C, the number of water units in the basin depended on how much water had been passed on from the upstream region.

B) Water Units Out: The number of water units with which each region ended after their allocations to their region's four sectors. The number of water units out for a particular region would be the amount of water that would be passed on to the downstream region.

e. Sectors: Participants allocated to four sectors: industry, agriculture, municipal, and environmental services (as discussed in Section 3.2).

f. Points: The economic value of each sector, based on its water demand, created a weighted value for each unit of water allocated to the specified sectors. These values were simplified and referred to as "points" during the experiment (as discussed in Section 3.2; see Appendix A)

We conducted an analysis of variance (ANOVA) to determine whether significant differences in water allocations existed among the three different policies. We also used an ANOVA to determine whether significant differences in allocations existed among regions under the three policy rule sets and two water level scenarios.

To address the effect of drought conditions, we conducted a one-sample *t*-test for Policies 1 and 2 and an ANOVA for Policy 3 to determine the effect of water levels on points and water units in and out when there was 81% water availability compared with 45% water availability.

To address how the participants allocated water to the different sectors, we conducted a mean comparison and ANOVA to determine whether significant differences existed in patterns of allocation to different sectors under the three policies and two water level scenarios. We performed a qualitative analysis of participants' allocation strategies using NVivo 10 to interpret the communication sessions among participants.

5. Results

Policy and the presence of drought conditions had statistically significant effects on allocation decisions. Differences between the three policies, however, were not as large as expected. Two factors may have contributed to this result. First, participants in the experiment had extensive knowledge of the Saskatchewan River Basin, including the allocation rules set by the 1969 Master Agreement. Additionally, participants' prior knowledge of water allocation was primed by running Policy 1 (the one assuming the Master Agreement was still in place) and invoking participants' existing knowledge of the issue. Even when the rules allowed them to vary from the Master Agreement and coordinate with other regions, many of the participants reproduced the allocation scheme of the status quo, passing on 50% of their available water units to the downstream province. The trend was supported by a large amount of qualitative data in which many participants reported that they had defaulted to the Master Agreement allocation rules.

In addition, the experiment's design did not incentivize individual participants to satisfy their particular region's water demands. Because participants did not know the water demands of other regions, they were conservative and limited allocations of their region's water units. While those factors affected the results, those factors also provide evidence that the trends apparent in the results might have greater implications in a real-world scenario.

5.1 Policy

Results from the decision experiment showed that Policy 2 significantly affected participants' water allocation decisions under the 81% water availability scenario for water in ($F[24,23] = 207.78$, $p < .001$) and water out ($F[32,15] = 3.65$, $p = .005$), but it did not affect points (see Table 2). Policy 2 significantly affected participants' water allocation decisions under the 45% water availability scenario for water in ($F[18,30] = 74.35$, $p < .001$) and water out ($F[25,23] = 10.59$, $p < .001$), but, again, it did not affect points (see Table 2). Policy 3 significantly affected participants' water allocation decisions under the 81% water availability scenario for water in ($F[30,32] = 26.49$, $p < .001$) and water out ($F[42,20] = 5.84$, $p < .001$) but, as with the other two, it did not affect points. Policy 3 significantly affected participants' water allocation decisions under the 45% water availability scenario for water in ($F[23,40] = 24.07$, p

$<.001$) and water out ($F[28,35] = 6.27$, $p < .001$), but, in keeping with the trend, it did not affect points (Table 2).

Participants' allocation patterns under Policy 1 and Policy 3 resulted in comparable means for the number of water units flowing through the river basin (water units in and out of each region), suggesting that communication did not substantially affect allocation decisions. However, significant differences existed between Policy 2 and Policies 1 and 3, such as consistently fewer water units flowing through the river basin in Policy 2 than under Policies 1 and 3, which resulted from a larger number of water units used for the various economic purposes within the basin. The increase in water units used under the Policy 2 scenarios does not, in itself, indicate a poor policy option, particularly if the increased water use distributes benefits equitably throughout the entire basin. A comparison of the three policies' impacts on the amount of water entering the individual regions in the decision experiment (see Table 3) indicates that, under Policy 2, more water was used by Regions A and B. Policy 2's added flexibility gave participants more freedom in their allocations, and without a defined allocation rule set, participants may have been less aware of downstream needs, resulting in an increase in water use for Regions A and B. This result still needs to be considered, however, in light of the fact that many participants in the experiment defaulted to the Master Agreement (Policy 1) allocation rules. Had participants in the experiment not had extensive knowledge of the Master Agreement allocation rules, water use for Regions A and B under Policy 2 would likely have been higher, resulting in even lower inflow for Region C. The experiment highlighted the inherent disadvantage to downstream users unless strong policies such as the Master Agreement are in place to protect their allocations.

Table 2. ANOVA for Water Allocations Based on Policy Under 81% and 45% Water Availability

Water Availability 81%	**Policy 1**		**Policy 2**		**Policy 3**	
	M	***SD***	***M***	***SD***	***M***	***SD***
Points	6908.13	1878.55	7438.61	1547.57	7108.72	1899.30
Water In	64.78**	23.53	63.55**	23.12	65.94**	22.73
Water Out	45.60**	18.48	42.16*	15.29	46.94**	17.69
Water Availability 45%						
Points	4814.30	1679.32	5000.06	1625.72	4717.31	1805.04
Water In	35.31**	13.11	34.31**	13.97	35.27**	13.97
Water Out	23.41**	9.95	21.29**	9.88	23.25**	11.18

*Note. *p ≤ .010. ** p ≤ .001. Otherwise p > .050.*

Table 3. Means and Standard Deviations for Water Units into Each Region under the Three Policies and Two Water Availability Scenarios

Water In	**Policy 1**		**Policy 2**		**Policy 3**	
Water Availability 81%	***M***	***SD***	***M***	***SD***	***M***	***SD***
Region A	90	0	90	0	90	0
Region B	58.86	13.25	56.65	9.87	60.50	14.22
Region C	39.78	15.30	37.93	10.77	43.11	15.69
Water Availability 45%						
Region A	50	0	50	0	50	0
Region B	32.68	6.15	31.59	5.52	33.41	7.84
Region C	20.58	6.64	17.43	5.06	19.58	8.36

Policy 2’s higher overall water consumption was evident under both the 81% and 45% water availability scenarios. This consumption had more impact on downstream users in the 45% availability (severe drought) scenario. In Policy 2’s severe drought scenario, Region C received 3.15 fewer units than it did under Policy 1 ($F[2,61] = 177.28$, $p < .001$) and 2.15 fewer units than it did under Policy 3 ($F[2,61] = 116.65$, $p < .001$). Although the gain or loss of 2.15–3.15 water units is relatively inconsequential—taking into account the larger water demands of Regions A and B—it is significant for Region C because that region's overall water demand could be met with substantially less water in comparison to A and B. Therefore, the loss of 2.15–3.15 water units equalled enough water to fulfill 8%–11% of C's overall water demand, a large proportion under severe drought conditions. Thus, under the Policy 2 scenario, the absence of a defined allocation rule set or element of communication between riparian regions fostered a less equitable water distribution pattern and had negative ramifications for the downstream region.

A further examination of the results showed which policy option most equitably distributed water throughout the basin during the severe drought scenario. Policy 1's defined minimum flows resulted in the largest amount of water reaching Region C and ensured the most equitable distribution of water to the three regions (see Table 2). Based on these results, Policy 1's defined minimum flows ensured the most equitable distribution of water throughout the river basin under severe drought conditions.

5.2 Policy-Specific Qualitative Findings

Qualitative analysis of participants' allocation strategies under the three policy scenarios showed that many participants anchored on the Policy 1 Master Agreement allocation style for all three policy scenarios. Commenting on why this was the case, one participant stated that their allocations under Policy 2 and 3 were "similar [to] Policy 1; even though [I] don't need to pass on 50% [I] feel morally [and] ethically obligated to do so." This comment was similar to a large portion of participant comments, many of which mentioned that regardless of what sectors they were prioritizing, they "tried to remain as close as possible to the 50% policy" A reason for this appeared to be many participants' concerns with providing enough water to the downstream regions, with comments such as "I tried to meet provincial demands in a way that I can . . . deliver enough water downstream." While the desire to pass on substantial amounts of water was nearly universal, participants approached it from varying perspectives, with the more pessimistic participants feeling the need to compensate for other regions' lack of generosity with their downstream flows. One participant commented,

> No allocation rules is a bad thing. Not all regions will have a similar mindset. I think my upstream user has a large bias in one of the sectors, so I need to compensate in order to provide [a] good supply to my downstream user.

Other participants appeared more optimistic when equitably dividing the basin's water resources. One participant commented, "Seems only fair to give downstream provinces/regions about 50% of what we have. It's about the right for water/to water."

Under the Policy 3 scenarios, where participants in one region could communicate with the other regions for the first time in the experiment, many participants noted that they slightly altered their allocation strategies in conjunction with their group's discussion of basin needs and how they each should allocate. Many participants felt that Policy 3 was the best policy option because of this added communication; they could equitably allocate to meet the needs of everyone in the basin. However, it is important to note that a number of participants in the experiment were aware of the fragile nature of riparian cooperation when no fixed rule set was in place. A downstream participant summed up this issue:

> You sure do not want to be in Region C when relations break down and those upstream have all control of whether or not to let you have any water. I was happy to see that Regions A and B left some water for us . . . in Region C. I believe we need to focus on those relationships and continue to work together, as it is much more important during "crisis" moments than when all is well on the river.

5.3 Water Availability

Water availability had a statistically significant effect on participants' allocation decisions. Under Policy 1, drought conditions significantly affected the basin's points total ($t[62] = 29.19$, $p < .001$), the number of water units in ($t[62] = 21.86$, $p < .001$), and the number of water units out ($t[62] = 19.60$, $p < .001$). Under Policy 2, drought conditions significantly affected the basin's points total ($t[48] = 33.64$, $p < .001$), the number of water units in ($t[48] = 19.24$, $p < .001$), and the number of water units out ($t[48] = 19.30$, p < .001). Under Policy 3, drought conditions significantly affected the basin's number of water units in ($F[2,61] = 83.91$, $p < .001$) and the number of water units out ($F[2,61] = 15.83$, $p < .001$) when there was 81% water availability compared to 45% water availability. In the Policy 3 scenario, however, there was no significant effect on points ($F[2,61] = 2.11$, $p = .131$), which appears to be due to a large variation in how points were accumulated when participants were able to communicate.

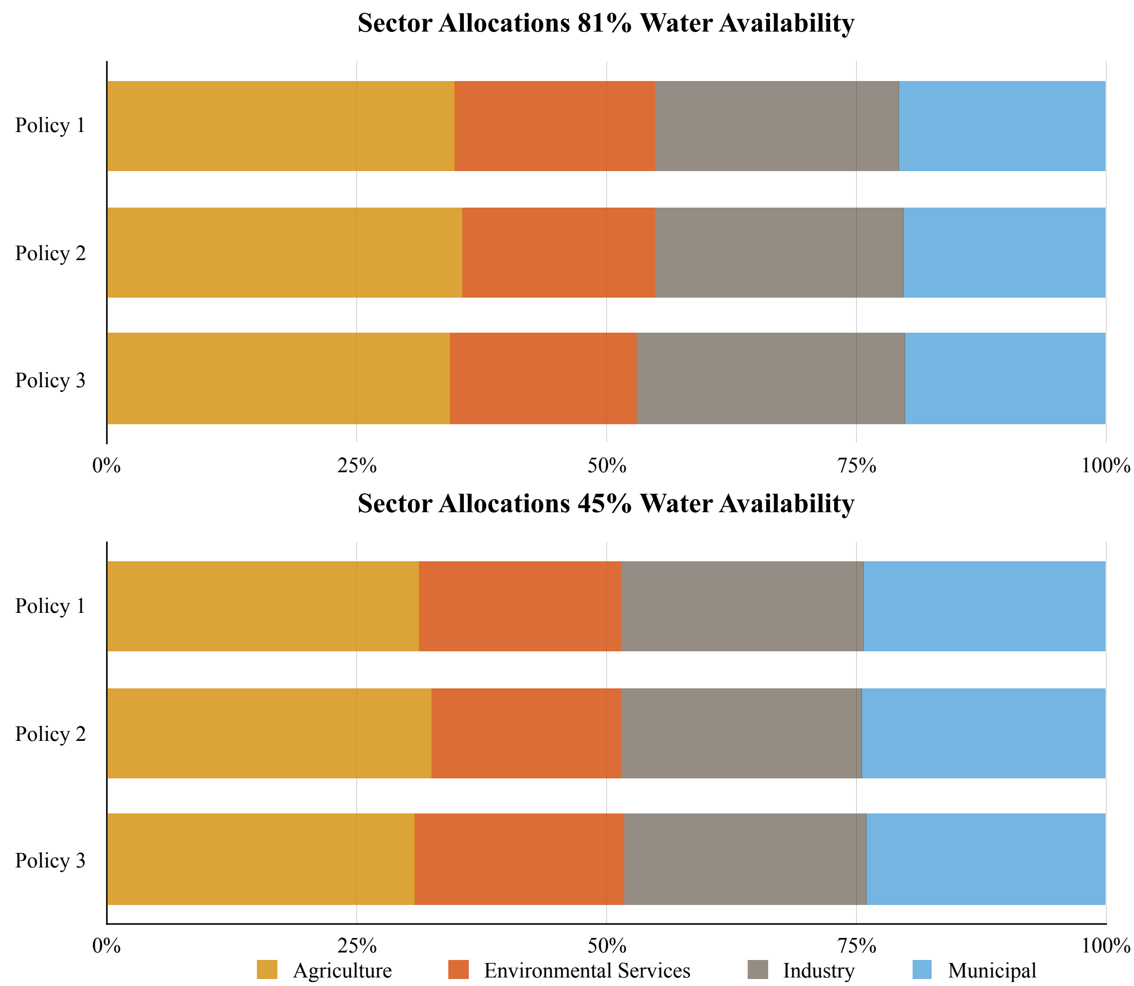


Fig. 3. Percentages of basin water unit allocations to the four sectors under the three policies and two water availability scenarios.

Water levels affected participants' allocation decisions not only with regard to how much was used but also with regard to where it could go, particularly when the number of available water units was reduced. Under the 45% water availability (severe drought) scenario, participants tended to reduce the basin's allocations to the agriculture sector and increase allocations to the municipal sector. When the number of available water units was reduced under the severe drought scenario, participants reduced the basin's agricultural water allocation from an average of 34.86% to 31.44%. The 3.42% decrease to the agriculture sector corresponded with an increase in water allocated to the municipal sector, from an average of 20.36% to 24.28% of the basin's water allocation. Additionally, under the severe drought scenario, participants reduced the basin's industry allocation by 1.3% (25.43% to 24.43%) and increased allocations to the environmental services sectors by .79% (19.35% to 20.14%).

The largest water use trade-off from agriculture to municipal usage warrants closer examination to understand the trade-off's implications. The 3.42% decrease in the basin's overall water allocations to agriculture under the severe drought scenario resulted in an average 24.17% decrease of the basin's ability to satisfy the agriculture sector's water demand. Meanwhile, the corresponding 3.92% increase in the basin's overall water allocations to the municipal sector under the 45% water availability scenario resulted in an average decrease of 15.94% in the basin's ability to satisfy the municipal sector's water demands. This was a considerably smaller decrease in ability to satisfy demand compared to the decrease for the agriculture sector.

Participants therefore used the reduction in water to the agriculture sector to ensure a smaller loss for the municipal sector. Looking at how this result affected the individual regions, we can clearly see that the three regions did not experience equal outcomes. Table 4 shows the average percentage of each region's ability to satisfy sector demands under the three policies in both the 81% and 45% water availability scenarios. These results showed that under both water level scenarios, considerably less demand was met upstream compared to downstream. Two factors contributed to this result. First, Regions A and B had higher overall water demands, whereas Region C had considerably lower demands, allowing a higher ratio of its demands to be met with less water. Second, these results highlighted the conservative allocation by participants in the experiment. Many participants, particularly those situated upstream, commented that they would have been more generous in their allocations had they known the water demands of the different regions. Participants also stated that their allocation decisions would have been very different if an incentive or disincentive existed to provide as much water as possible to the region for which they were allocating.

Table 4. Regions' Average Sector Water Demand Met Under the Two Water Availability Levels

Sector	Industry		Agriculture		Environmental Services		Municipal	
Water Availability	**81%**	**45%**	**81%**	**45%**	**81%**	**45%**	**81%**	**45%**
Region A (Alberta)	62%	38%%	60%	32%	66%	41%	77%	55%
Region B (Saskatchewan)	79%	66%	67%	45%	74%	65%	80%	68%
Region C (Manitoba)	83%	50%	85%	63%	81%	64%	92%	78%

Although it is unlikely that a real-world scenario would exactly duplicate the results of how these allocations affected each region, the trade-off implications are important. Notably, participants sought a trade-off of water allocations, minimizing the allocations to agriculture and industry and prioritizing the municipal sector under the severe drought scenario. Many participants viewed this trade-off as necessary to preserve social equity, the economic stability, and their region's environmental integrity.

5.5 Water Availability Key Qualitative Findings

A qualitative analysis of the participants' allocation strategies under the two water availability levels emphasized the key trade-off of agriculture to prioritize the municipal sector under the severe drought scenario. The majority of participants appeared to have chosen this trade-off because, as one participant commented, "it was the most water-demanding sector and had the lowest return [flow]." In turn, the majority of participants appear to have prioritized the municipal sector for human needs. One participant commented that they "decided to prioritize municipalities, specifically domestic water, as this is a life necessity." In post-experiment discussions, many participants noted that their decision to allocate water to the municipal sector was based on human fundamental needs for water to survive. Participants almost universally deprioritized the agriculture sector, which had the largest water demand in the interactive basin, no return flow, and relatively little point return in comparison to other sectors; the majority of participants believed this trade-off was necessary to better preserve the social equity, economic stability and environmental integrity of the river basin.

The secondary trade-off evident from the experiment was the reduction in water allocated to the industrial sector. Although this reduction was less drastic than the reduction in water to the agriculture sector under the severe drought scenario, a word frequency analysis of participant allocation strategies showed that industry was the most frequently mentioned sector (mentioned 25% more than any other sector in the 81% water availability scenario and 37% more in the 45% water availability scenario). Even though industry was evidently a major consideration in participants' allocation strategies, opinions and subsequent allocations to industry appeared to be largely divided. Some participants held that the industrial sector should be prioritized to preserve the economy; with participants commenting that they're allocation strategy was to provide greater allocations to industry to "keep up the economy." One participant even noted they "maxed out industry to keep the economy moving." It is important to note that many participants who believed the industrial sector should be prioritized did express that in addition to its economic benefits, the industrial sector in the experiment had relatively high return flows and noted that greater allocations to industry would allow a higher percentage of water to be passed downstream.

While a good proportion of participants evidently prioritized the industrial sector, other participants viewed it as nonessential during times of drought and supported reducing water allocations to the industrial sector. Many of the participants that reduced their allocations to the industrial sector appeared to believe that industry would "need to adapt" and that "[water] limitation[s] will drive innovation [for water conservation]". This ideological divide resulted in minor changes to the percentage of water allocated to the industrial sector across the basin under the severe drought scenario.

At the outset of this experiment, we were uncertain how participants would allocate water to the environmental services sector, particularly because they would lose points for doing so. Surprisingly, under both water availability scenarios, participants consistently allocated water to the environment. As the environmental sector had a 100% return flow, it served to ensure higher water flows to the downstream regions. However, participants could have chosen simply not to allocate to the environment, which would have resulted in the same amount of water flowing downstream but would not have caused a loss of points. When asked why they allocated to the environment, participants had mixed responses. Some participants mentioned the sustainability of the water system and surrounding ecosystems, whereas other participants expressed the view that it was "simply the right thing to do" or felt they were morally obligated to allocate to the environment. Although there were no obvious benefits to the participants to allocate to the environment, they did so anyway; we can extrapolate that allocations to this sector would have been greater had we assigned positive points to environmental services.

6. Discussion

Although policies affected the difference between participant allocation patterns less than we expected at the outset of the experiment, the results yielded insight into the effects of rule structures for managing a scarce resource such as water. Significantly, water was more equitably distributed throughout the river basin under Policies 1 (status quo) and 3 (community of interest) than under Policy 2 (no rules) in the decision experiment. This implies that when there is a defined minimum flow rule set or when riparian users communicate well, water will be more equitably distributed than in a scenario where the rules of allocation are unclear and communication and coordination are not present. This result is consistent with the current water allocation theories on which we based the policies tested in this experiment (Cascao & Zeitoun, 2010; McCaffery, 2007; McIntyre, 2010; Versteeg, 2007).

In the 81% water availability scenario, Policy 3 most equitably distributed water throughout the river basin—slightly (though significant statistically) outperforming Policy 1. In this scenario, nearly all participants expressed the belief that Policy 3 was the most equitable policy option. Participants believed that coming together as a basin group to share information, discuss one another's needs, and agree on the necessary trade-offs ensured the most equitable distribution of water between the three regions. The elements of communication and riparian partnership, seen in the results under Policy 3, are consistent with the current literature, supporting the theory that these elements are critical to forming the community of interest principle, which is the ideal allocation theory for water management (Cascao & Zeitoun, 2010; McCaffery, 2007; McIntyre, 2010; Versteeg, 2007). Respect for and consideration of one another's interests, manifested through the principles of prior notification, consultation, and negotiation concerning changes in the use of water resources, are key to maintaining the relationship between riparian bodies (Cascao & Zeitoun, 2010; Lubell, Schneider, Scholz, & Mete, 2002; McCaffery, 2007).

It must be remembered, however, that the results noted above were created under fictitious experimental conditions and many of the participants already had good working relationships. They also had the incentive to work together despite acting individually to allocate water resources to their specified region (Mercer, 2005; Thaler & Sunstein, 2009). We may assume that if participants were given individual incentives to provide as much water as possible to their respective regions and had perceived different levels of gains or losses as a result, the incentive to work with the other riparian bodies would have been diluted, changing the relationship between participants (Kahneman & Tversky, 1983; Mercer, 2005; Thaler & Sunstein, 2009). In turn, the community of interest principle might then have lacked the elements necessary to succeed, making it difficult to replicate the results of this decision experiment. Essentially, the process may not work in real life as it did in the experiment because factors are involved that we could not simulate here.

The same assumptions of change in allocation patterns can be made when we consider the effects of policy on participants' allocation decisions under the severe drought scenario. Although Policy 1 ensured the most equitable distribution of water throughout the basin, the majority of participants, who were unaware of the actual results at the time, expressed the view that, even under the severe drought scenario, they believed that Policy 3 most equitably distributed water throughout the river basin. They also highlighted that the element of communication was an integral factor in making decisions under the severe drought scenario because it allowed them to better understand one another's individual needs and priorities and therefore make the necessary trade-offs. However, we may again assume that if participants had had individual incentives that altered their perception of gain or loss, the results seen under Policy 3 would be difficult to replicate. Because the number of available water units in this scenario was reduced dramatically, participants would probably manifest a greater concern for their individual regions' well-being and would be likely to allocate more water to their own regions to attempt to offset a sense of loss or deprivation.

In comparison, the defined minimum flow rule set in Policy 1 would be more resilient to changes in participant relationships and differing incentives. As long as the defined minimum flow rule is upheld, each region is ensured an equitable share of the available water. As a result, in severe drought scenarios, a defined minimum flow rule set appears vital for ensuring the equitable distribution of water resources; in addition, it is more resilient against a variety of factors that affect decision-making (Cascao & Zeitoun, 2010; Lubell et al., 2002; McCaffery, 2007).

These results clearly demonstrate that policies containing provisions with a defined minimum flow rule set are useful to ensure a baseline for the equitable distribution of water. Additionally, these results show the potential benefits riparian bodies can gain from greater cooperation and communication, indicating that the optimal policy option contains provisions with defined minimum flow but also mandates communication and cooperation among riparian bodies. These findings are consistent with Lubell et al.'s (2002) conclusions that, as water stakeholders begin to realize that cooperation between riparian users may be less costly than lack of cooperation, partnerships are more likely to emerge. However, for these partnerships to be successful, effective regulation must be in place to guide the actions of those involved (Cascao & Zeitoun, 2010; Lubell et al., 2002).

This examination of the effects of policy on participant allocations provides insight for stakeholders and decision makers in the Saskatchewan River Basin into how different policies affect allocation decisions and what policy or policy combination may be most optimal for the equitable distribution of water under normal and drought conditions. First, the experiment's results showed the effectiveness of the 1969 Master Agreement of Apportionment rule set, particularly for maintaining the equitable distribution of water to the individual provinces during drought conditions. The experiment clarified the functionality and benefits of this agreement, with results matching that of the actual Master Agreement's effectiveness since its inception in 1969. However, some question exists regarding whether the results seen under the severe drought scenario would also occur in reality. Despite the agreement's inception in 1969, it has rarely been significantly tested; the main exception was the drought in 2001, when Alberta came close to breaching the Master Agreement by nearly failing to pass the agreed-upon volume of water to Saskatchewan (Gober & Wheater, 2014; Wandel, Young & Smit, 2009). Considering that that near-breach occurred within what was a relatively short drought, there is concern and uncertainty about how resilient the Master Agreement would be during prolonged drought conditions in the future.

In this experiment, it was impossible for the participants to breach the Master Agreement rules—something that could certainly happen in reality. What each of the three provinces would actually do under extreme drought conditions can be predicted only by their past actions under similar conditions or through experimental exercises such as the one discussed in this and other studies (Fishman, 2011; Wandel et al., 2009). Water managers in the Saskatchewan River Basin must consider what actions they might take in scenarios more severe than what has been seen in the past. Water managers should review provisions and consider what actions they could take if the Master Agreement were to be breached and fashion a relevant timeline for enabling these processes. Current provisions within the Master Agreement mandate that the Federal Court of Canada determine any dispute, pointing to an uncertain and timely resolution strategy; pre-emptively considering new resolution provisions could limit the possible negative effects of a breach in the agreement (Hurlbert, 2009; Lempert & Schlesinger, 2000).

The results of the decision experiment also indicated that greater cooperation and communication among riparian bodies may ensure equitable allocation of water. In reality, however, adequate communication appears to be a practice with which many riparian bodies struggle, leading to less effective and efficient water management. The complex nature of water management is a major factor hindering effective communication among riparian bodies. Because water is used in so many different ways, it is hard enough for individual riparian bodies to understand and judiciously act on their own needs, let alone to express those needs to other riparian bodies while simultaneously attempting to balance the needs and wishes of other bodies (Fishman, 2011). Although the Prairie Provinces are generally entitled to manage their provincial water resources individually, the management structure of water usage is fragmented by the multiple governing agencies within each province, each with varying mandates and responsibilities for the allocation, management, and protection of water resources (Partners for the Saskatchewan River Basin, 2009b). This complex web of managerial bodies throughout the Prairie Provinces makes it difficult to establish and maintain fluid communication between organizations and, on a larger scale, may foster a competitive relationship among the Prairie Provinces over water use (Fishman, 2011).

Fluid communication, however, is immensely beneficial. In fact, the majority of experiment participants expressed surprise at how much easier their task became when they were permitted to communicate. In the experiment debrief, many participants stated that the experiment made them realize the importance of communication with other regions, enabling more effective basin-level water management and more efficient decision-making, particularly under severe drought conditions.

The fragmented managerial structure that exists within the Prairie Provinces poses a challenge to the effective management and protection of water resources. However, as considering the human dimension of water management becomes more strategic, we have cause for optimism (Fishman, 2011; Gober et al., 2015). Studies such as this experiment or other workshops and activities may help to build a stronger relationship among water stakeholders and decision makers across the Prairie Provinces, which in turn can help create more effective and efficient water management policies (Hill et al., 2014; Rusca, Heun, & Schwartz, 2012). These stronger relationships will be particularly valuable under drought conditions, when better cooperation and communication will allow for the creation of more adaptive management plans that can be implemented in advance of drought situations. By planning ahead, we can reduce the amount of crisis-condition decision making while ensuring that we achieve the most equitable balance of water allocation to meet the needs of the region and population.

The experimental results have important implications for the Saskatchewan River Basin and the Prairie Provinces. This decision experiment shed light on what stakeholders and decision makers within the Saskatchewan River Basin might prioritize during times of severe drought conditions and provided examples of trade-offs used to manage water under such conditions. Results seen in the decision experiment mimicked the actions taken in Alberta in 2001, providing evidence of consistent behaviour in drought conditions in the prairies (Gober & Wheater, 2014; Wandel et al., 2009). These results could contribute to the development of more adaptive management practices, reducing the uncertainty of stakeholders' and decision makers' actions during times of water stress. Additionally, these results could assist Saskatchewan in clarifying water license priorities, including stakeholders from the provinces in an effort to communicate clearly as well as allow interested parties to share their concerns and priorities (Hurlbert, 2006, 2009). In turn, this may help reduce conflicts among stakeholders and help create better measures to deal with possible water shortages in the future.

This innovative decision experiment provided insight into the effects of policy on water allocation decisions and clarified participant priorities during times of shortage. However we must note that the experiment was imperfect and presented a number of limitations that must be considered. First, we found that participants anchored on the 1969 Master Agreement of Apportionment allocation style for all of their allocations, which minimized the difference in allocation patterns for the different policy treatments. In the future, running the "no rule set" scenario first may be a better option, giving participants an opportunity to allocate with less of an anchoring mechanism in place.

Second, incentives were too low to have a significant impact on how the majority of participants allocated their water resources in the decision experiment. Moreover, having a group incentive makes participants very conservative with their allocations; they also worked together far better than outside riparian users might. Offering greater incentives to the individual regions within each basin would likely change how participants allocate water resources, better simulating real-world economics.

Third, the decision experiment intentionally excluded a water quality measure for the purpose of reducing the experiment's complexity. The majority of participants commented that their decisions would have been slightly different had there been some type of water quality meter or narrative of consequence. It would therefore be valuable to add a water quality element to a second variation to observe its effect on participant allocation patterns.

7. Conclusion

In summary, this decision experiment evaluated the effects of policy context and drought conditions on water allocation decision making in the Saskatchewan River Basin. Our results displayed the effectiveness of policies with defined minimum flows and communication among stakeholders. Participants made expected choices to protect municipal water use at the expense of agriculture, and to a smaller extent industry, in the face of water shortage conditions.

Results should be interpreted with caution because participants were in no way chosen randomly. They had considerable experience with the problem at hand, and while the actual differences between policy and drought treatments were statistically significant, they were still relatively small. However, the results demonstrated that insight can be gained from experiments of this sort and that valuable social learning can occur. They also suggested the importance of preparing for drought conditions by implementing both a formal rule structure to oversee allocations or ongoing communications processes that allow difficult problems to be resolved.

Although the experiment was far from perfect, it could offer insight into possible applications in the future and could also be adapted to mimic nearly any river basin, provided the number of riparian bodies is known and the key water use sectors and estimated water use or licensed allocation of those sectors can be identified. This decision experiment has the potential for use by other water managers or stakeholders to gain insight into a variety of water management questions, which could contribute to the adaptive capacity of stakeholders and decision makers and assist with water management and planning under uncertain conditions.

References

AMEC. (2009). *South Saskatchewan River basin in Alberta: Water supply study.* Lethbridge, AB: Alberta Agriculture and Rural Development.

Bildhaeuser, S. (2010). *Institutions of water management and conflict resolution in Lesotho on local level: An empirical study of displacement areas of the Lesotho Highlands Water Project.* MICROCON Research Working Paper 22, Brighton, UK: MICROCON.

Birnie, P., Boyle, A., & Redgwell, C. (2009). *International law and the environment* (3rd ed.) Oxford, UK: Oxford University Press.

Böhmelt, T., Bernauer, T., Buhaug, H., Gleditsch, N. P., Tribaldos, T., & Wischnath, G. (2014). Demand, supply, and restraint: Determinants of domestic water conflict and cooperation. *Global Environmental Change*, *29*, 337–348. doi:10.1016/j.gloenvcha.2013.11.018.

Bonsal, B., Aider, R., Gachon, P., & Lapp, S. (2013). An assessment of Canadian prairie drought: Past, present, and future. *Climate Dynamics, 41*(2), 501–516.

Canadian Hydropower Association. (2014). *Report of activities*. Retrieved from https://canadahydro.ca/system/resources/.../CHA-AR13-e-v5-web.pdf

Cascao, A., & Zeitoun, M. (2010). Power, hegemony and critical hydropolitics. In Earle et al. (Eds.), *Transboundary water management: Principles and practice.* (pp. 27–42). Washington, DC: Earthscan.

Case, R. A., & MacDonald, G. M. (2003, June). Tree ring reconstructions of streamflow for three Canadian prairie rivers. *Journal of the American Water Resources Association,* 703–716.

Comeau, L. E. L., Pietroniro, A., & Demuth, M. N. (2009). Glacier contribution to the North and South Saskatchewan Rivers. *Hydrological Process, 23*(18), 2640–2653. doi:10.1002/hyp.7409

Demuth, M. N., & Pietroniro, A. (2003). *Prairie adaptation research collaborative, study report project P55*. Regina, SK: Prairie Adaptation Research Collaborative.

Dey, A. K. (2014). *Surface water licensing, water using licensing section*. Province of Manitoba. Personal Communication.

Earle, A., Jagerskog, A., & Ojendal, J. (2010). *Transboundary water management principles and practice* (1st ed.). Washington, DC: Earthscan.

Edenhofer, O., et al. (Eds.). (2011). *IPCC special report on renewable energy sources and climate change mitigation.* Cambridge, UK: Cambridge University Press.

Fehr, E., & Falk, A. (2002). *Psychological foundations of incentives.* European Economic Review, 2002, *46*(4), 687–724.

Fishman, C. (2011). *The big thirst: The secret life and turbulent future of water* (1st ed.). New York, NY: Free Press.

Great Depression. (2015). In *Encyclopaedia of Saskatchewan*. Retrieved from http://esask.uregina.ca/entry/great_depression.html

Gober, P. A., Strickert, G. E., Clark, D. A., Chun, K. P., Payton, D., & Bruce, K. (2015). Divergent perspectives on water security: Bridging the policy debate. *The Professional Geographer*, *67*(1), 62–71. doi:10.1080/00330124.2014.883960.

Gober, P., & Wheater, H. S. (2014). Socio-hydrology and the science–policy interface: A case study of the Saskatchewan River Basin. *Hydrology and Earth System Sciences, 18*(4), 1413–1422. doi:10.5194/hess-18-1413-2014.

Government of Alberta. (2010). *Facts about water in Alberta*, Edmonton, AB. Retrieved from: http://environment.gov.ab.ca/info/library/6364.pdf

Hanak, E., Lund, J., Dinar, A., Gray, B., Howitt, H., Mount, J., . . . Thompson, B. (2011). *Managing California's water: From conflict to reconciliation.* Retrieved from http://www.ppic.org/main/publication.asp?i=944

Hand, M. M., et al. (Eds). (2012). *Renewable electricity futures study*. NREL/TP-6A20-52409. Retrieved from http://www.nrel.gov/analysis/re_futures/

Haug, C., Huitema, D., & Wenzler, I. (2011). Learning through games? Evaluating the learning effect of a policy exercise on European climate policy. *Technological Forecasting and Social Change, 78*(6), 968–981. doi:10.1016/j.techfore.2010.12.001.

Hill, H., Hadarits, M., Rieger, R., Strickert, G., Davies, E., & Strobbe, K. (2014). The invitational drought tournament: What is it and why is it a useful tool for drought preparedness and adaptation? *Weather and Climate Extremes, 3*, 107–116.

Hu, Q., Johnston, E., Hemphill, L., Krishnamurthy, R., & Vinze, A. (2012). Exploring the role of interactive computer simulations in public administration education. *Journal of Public Affairs Education, 18*(3), 513–530.

Hurlbert, M. (2006). *Water law in the South Saskatchewan River Basin (Alberta/Saskatchewan)*. No. 27. Regina, SK: Author.

Hurlbert, M. (2009). Comparative water governance in the four western provinces. *Prairie Forum, 34*(1), 45–77.

Hurlbert, M., Corkal, D. R., & Diaz, H. (2009). Government and civil society: Adaptive water management in the South Saskatchewan River Basin. *Prairie Forum, 34*(1), 181–210.

Hydro Quebec. (2014). *Comparison of electricity prices in major North American cities*. Retrieved from http://www.hydroquebec.com/publications/en/corporate-documents/comparaison-electricity-prices.html

Kahneman, D., & Tversky, A. (1983). Choices, values, and frames. *American Psychologist, 39*(4), 341–350.

Kulshreshtha, S., Bogdan, A., & Nagy, C. (2012). *Present and future water demand in Saskatchewan—A summary by river basins*. Saskatoon, SK: University of Saskatchewan.

Lach, D., Ingram, H., & Rayner, S. (2005). Maintaining the status quo: How institutional norms and practices create conservative water organizations. *Texas Law Review, 83*, 2027–2185.

Lempert, R. J., & Schlesinger, M. E. (2000). Robust strategies for abating climate change. *Climate Change, 45*(3) 387–401.

Little, J. (2001) *Water quality in the battersea drain and lower little bow river (1998–2000)—Interim report.* Lethbridge, AB: Irrigation Branch, Alberta Agriculture, Food and Rural Development.

Lubell, M., Schneider, M., Scholz, J. T., & Mete, M. (2002). Watershed partnerships and the emergence of collective action institutions. *American Journal of Political Science, 46*(1), 148–163.

Marshall, S. J., White, E., Demuth, M., Bolch, T., Wheate, R., Menounos, B., . . .Shea, J. (2011). Glacier water resources on the eastern slopes of the Canadian Rocky Mountains. *Canadian Water Resources Journal, 36*(2), 109–134. doi:10.4296/cwrj3602823

Martz, L., Bruneau, J., Rolfe, T., Toth, B., Armstrong, R., Kulshreshtha, S., . . .Wagner, A. (2007.) *Climate change and water* (SSRB Final Technical Report). Saskatoon, SK: University of Saskatchewan.

McCaffrey, S. C. (2007). *The law of international watercourses* (2nd ed.). New York, NY: Oxford University Press.

McIntyre, O. (2010). International water law: Concepts, evolution and development. In Earle et al. (Eds.), *Transboundary water management: Principles and practice* (pp. 59–71). Washington, DC: Earthscan.

Mercer, J. (2005). Prospect theory and political science. *Annual Review of Political Science, 8*, 1–21. doi:10.1146/annurev.polisci.8.082103.104911

Moore, R. D., Fleming, S. W., Menounos, B., Wheate, R., Fountain, A., Stahl, K., . . .Jakob, M. (2009). Glacier change in western North America: Influences on hydrology, geomorphic hazards and water quality. *Hydrological Process*, *23*(1), 42–61. doi:10.1002/hyp.7162

National Academy of Sciences. (2010). *Electricity from renewable resources: Status, prospects, and impediments.* Washington, DC: National Academies Press. Retrieved from http://www.nap.edu/openbook.php?record_id=12619

OECD. (2009). *Managing water for all: An OECD perspective on pricing and financing.* Retrieved from http://www.oecd.org/env/resources/ managingwaterforallanoecdperspectiveonpricingandfinancing.htm

Partners for the Saskatchewan River Basin. (2009a). *From the mountain to the sea: Summary of the state of the Saskatchewan River.* Retrieved from http://www.saskriverbasin.ca/page.php?page_id=70

Partners for the Saskatchewan River Basin. (2009b). *The state of the Saskatchewan River: Chapter 3: Institutional arrangements.* Retrieved from http://www.saskriverbasin.ca/page.php?page_id=70

Partners for the Saskatchewan River Basin. (2015). *Map of the Saskatchewan River Basin.* 1:100. Retrieved from http://www.saskriverbasin.ca/file/basin_map.pdf

Rusca, M., Heun, J., & Schwartz, K. (2012). Water management simulation games and the construction of knowledge. *Hydrology and Earth System Sciences, 16*(8), 2749–2757.

Saffran, K. (2005). *Oldman river basin water quality initiative, surface water quality summary report, April 1998–March 2003.* Retrieved from http://www.oldmanbasin.org/pdfs/ orbwqi_swq_98-03.pdf

Software Platform for Human Interaction Experiments (SoPHIE). (2015). Retrieved from http://www.sophie.uni-osnabrueck.de/about/

Thaler, R. H., & Sunstein, C. R. (2009). *Nudge: Improving decisions about health, wealth, and happiness*. London, UK: Penguin Books Ltd.

Versteeg, M. (2007). Equitable utilization or the right to water? Legal responses to global water scarcity. *Tilburg Foreign Law Review*, *13*(4), 368–392.

Vörösmarty, C. J., McIntyre, P. B., Gessner, M. O., Dudgeon, D., Prusevich, A., Green, P., . . . Davies, P. M. (2010). Global threats to human water security and river biodiversity. *Nature*, *467*(7315), 555–561.

Wandel, J., Young, G., & Smit, B. (2009). The 2001–2002 drought: Vulnerability and adaptation in Alberta's special areas. *Prairie Forum, 1*(1), 211–234.

Wheater, H., & Gober, P. (2013). Water security in the Canadian Prairies: science and management challenges. *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*, *371*(2002). 20120409.http://dx.doi.org/10.1098/rsta.2012.0409.

Appendices

Appendix A

(Background Experiment Data)

Table A1. Baseline of water units each sector receives at maximum water flow and corresponding point value per water unit.

	Units†	Units Passed On‡	Baseline	Per Capita GDP			Points (per water unit)§
Region A - Agriculture	41	0	41	$1,176.25	$28.69	$2.87	3
Region A - Municipal	16	14	16	$41,923.55	$2,620.22	$262.02	262
Region A - Industrial	29	22	29	$47,715.69	$1,645.37	$164.54	165
Region A - Environmental	25	25	25	$2,004.99	$80.20	$8.02	-20¶
Total	111	61	111				
Region B - Agriculture	23	0	23	$4,429.04	$192.57	$19.26	19
Region B - Municipal	12	10.8	12	$32,994.97	$2,749.58	$274.96	275
Region B - Industrial	3	2.25	3	$36,645.20	$12,215.07	$1,221.51	1222
Region B - Environmental	5	5	5	$2,378.07	$475.61	$47.56	-20¶
Total	55	18.05	43				
Region C - Agriculture	4	0	4	$1,778.52	$444.63	$44.46	44
Region C - Municipal	4	3.6	4	$14,169.01	$3,542.25	$354.23	354
Region C - Industrial	15	11.25	15	$35,006.16	$2,333.74	$233.37	233
Region C - Environmental	5	5	5	$2,353.84	$470.77	$47.08	-60¶
Total	28	19.85	28				

† Data based on water use percentages (Table A2). Exact percentages were modified slightly to create a simple working model.
‡ Data based on return flow percentages.
§ Data based on Labour Force Per Capita GDP (Table A3).
¶ Environmental services water demands were modified outside of the proportional calculations for the other sectors and corresponding GDP scores. This was because the additional environmental sectors' water demand was outside the licensing or water use data and the environmental services and hydropower sectors had their own relationship for how points were accumulated in the experiment. (Table A5).

Table A2. Water use percentages by sector.

Region	Upstream†	Midstream‡	Downstream§
Agriculture	44.3	56.3	15
Municipal	17.3	30.6	14
Industrial	31.9	8.1	64
Environmental Services	6.5	5	7
Total (%)	100	100	100

† Licensing data from Government of Alberta. (2010). *Facts about water in Alberta*, Edmonton, AB. Retrieved from: http://environment.gov.ab.ca/info/library/6364.pdf

‡ Because accurate licensing data for Saskatchewan were absent, the authors used Saskatchewan water use records in combination with licensing data from Alberta and Manitoba to create water use percentages for the Midstream region.
Water use data from Kulshreshtha, S., Bogdan, A., & Nagy, C. (2012). *Present and future water demand in Saskatchewan—A summary by river basins*. Saskatoon, SK: University of Saskatchewan.
Licensing data from Government of Alberta. (2010). *Facts about water in Alberta*, Edmonton, AB. Retrieved from: http://environment.gov.ab.ca/info/library/6364.pdf Dey, A. K. (2014). *Surface water licensing, water using licensing section*. Province of Manitoba. Personal Communication.
Additionally, data from Alberta's Water License Allocation Viewer were used. Retrieved from http://esrd.alberta.ca/water/programs-and-services/south-saskatchewan-river-basin-water-information/water-allocation-licence-viewer.aspx

§ Licensing data from Dey, A. K. (2014). *Surface water licensing, water using licensing section*. Province of Manitoba. Personal Communication.

Table A3. Provincial GDP and corresponding Per Capita GDP by experiment sector.

Population†	Alberta 2,818,960.00		Saskatchewan 792,745.00		Manitoba 925,040.00	
	GDP	Per Capita GDP‡	GDP	Per Capita GDP‡	GDP	Per Capita GDP‡
Agriculture	$3,315,800,000	$1,176.25	$3,511,100,000	$4,429.04	$1,645,200,000	$1,778.52
Municipal	$118,180,800,000	$41,923.55	$26,156,600,000	$32,994.97	$13,106,900,000	$14,169.01
Industrial	$134,508,600,000	$47,715.68	$29,050,300,000	$36,645.20	$32,382,100,000	$35,006.16
Environmental Services	$5,652,000,000	$2,004.99	$1,885,200,000	$2,378.07	$2,177,400,000	$2,353.84

† Labour Force Population September 2014. Source: Statistics Canada. Table 282-0087 – Labour force survey estimates, seasonally adjusted and unadjusted, CANSIM (database).
‡ Sector Per Capita GDP = (Sector GDP/ Province Population).

Table A4. Provincial gross domestic product (GDP) at basic prices, by sector and industry. Annual (2010) (Dollars x 1,000,000)

Experiment Sectors	Sectors	Alberta	%	Saskatchewan	%	Manitoba	%
Agriculture	Crop/animal production	$3,129.40	1.20	$3,428.20	5.66	$1,588.90	3.22
	Support activities for agriculture and forestry	$184.10	0.07	$80.10	0.13	$49.90	0.10
	Fishing, Hunting, and Trapping	$2.30	0.001	$2.80	0.00	$6.40	0.01
Industry	Forestry and logging	$318.10	0.12	$43.20	0.07	$21.00	0.04
	Transportation and warehousing	$10,866.90	4.15	$2,803.70	4.63	$2,791.10	5.66
	Mining, quarrying, and oil and gas	$63,460.90	24.25	$15,295.70	25.24	$1,974.50	4.00
	Residential construction	$5,351.60	2.05	$864.10	1.43	$819.50	1.66
	Non-residential building construction	$2,736.90	1.05	$663.00	1.09	$456.50	0.93
	Engineering construction	$14,273.10	5.45	$2,257.70	3.73	$1,230.80	2.50
	Repair construction	$2,342.70	0.90	$696.50	1.15	$704.90	1.43
	Other activities of the construction industry	$482.10	0.18	$33.20	0.05	$61.00	0.12
	Manufacturing	$18,348.50	7.01	$3,499.50	5.77	$5,047.60	10.24
	Utilities	$3,855.20	1.47	$1,205.90	1.99	$1,202.60	2.44
Municipal	Wholesale trade	$11,274.40	4.31	$2,895.10	4.78	$2,801.10	5.68
	Retail Trade	$11,720.00	4.48	$2,645.70	4.37	$2,794.00	5.67
	Information and cultural industries	$6,480.90	2.48	$1,076.40	1.78	$1,534.30	3.11
	Finance, insurance, real estate, rental and leasing, and holding companies	$21,641.60	8.27	$4,037.10	6.66	$5,006.30	10.15
	Owner occupied dwellings	$16,406.30	6.27	$4,137.10	6.83	$4,199.00	8.52
	Professional, scientific, and technical services	$14,134.90	5.40	$1,477.80	2.44	$1,442.50	2.93
	Administrative and support, waste management, and remediation services	$5,745.00	2.20	$689.60	1.14	$820.60	1.66
	Educational services	$339.60	0.13	$38.00	0.06	$48.50	0.10
	Health care and social assistance	$5,343.40	2.04	$919.10	1.52	$1,206.50	2.45
	Arts, entertainment, and recreation	$1,089.80	0.42	$309.40	0.51	$304.90	0.62

	Accommodation and food services	$5,104.20	1.95	$984.30	1.62	$931.60	1.89
	Other services (except public administration)	$4,115.20	1.57	$697.30	1.15	$669.20	1.36
	Non-profit institutions serving households	$2,115.50	0.81	$528.90	0.87	$884.10	1.79
	Government Education Services	$9,595.60	3.67	$2,690.90	4.44	$2,654.80	5.38
	Government health services	$5,928.00	2.27	$2,047.60	3.38	$2,355.30	4.78
	Other federal government services	$3,043.90	1.16	$1,056.60	1.74	$1,750.90	3.55
	Other municipal government services	$6,060.30	2.32	$1,163.30	1.92	$1,136.10	2.30
	Other aboriginal government services	$514.80	0.20	$450.20	0.74	$639.80	1.30
Environmental Services	Other provincial and territorial government services	$5,652.00	2.16	$1,885.20	3.11	$2,177.40	4.42
	Total	**261,657.20**	**100.00**	**60,603.20**	**100.00**	**49,311.60**	**100.00**

Table A5. Hydropower installed capacity and average price by province.

Province	Installed Capacity (kW)†	Average Price April 2014 ($/kWh)‡
Alberta	909,000	10.78
Saskatchewan	854,000	10.49
Manitoba	5,029,000	35.71

† Canadian Hydropower Association. (2014). *Report of activities*. Retrieved from https://canadahydro.ca/system/resources/.../CHA-AR13-e-v5-web.pdf:

‡ Data from Hydro Quebec. (2014). *Comparison of electricity prices in major North American cities*. Retrieved from http://www.hydroquebec.com/publications/en/corporate-documents/comparaison-electricity-prices.html

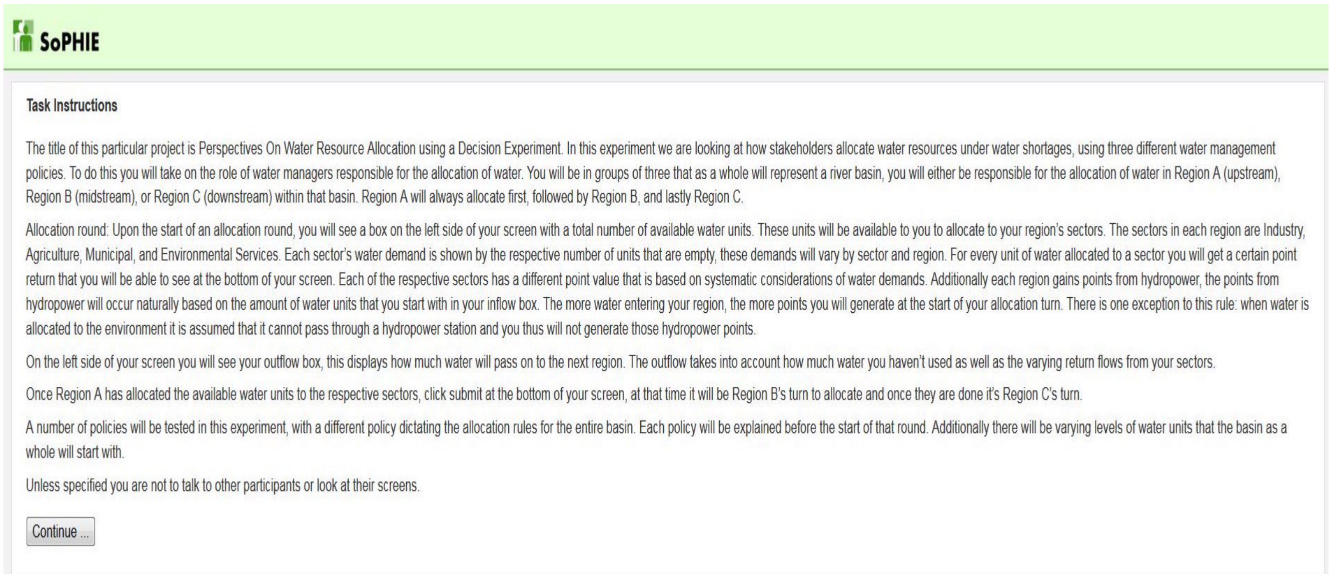
Appendix B

(Step-By-Step Guide Through Decision Experiment)

Step-By-Step Guide Through Decision Experiment

Figures will be numbered showing experiment stage and step within the stage. Example, Figure 1.1 represents stage 1, step one; Figure 1.2 represents stage 1, step 2; and so on.

Fig. 1.1. Task Instructions



SoPHIE

Task Instructions

The title of this particular project is Perspectives On Water Resource Allocation using a Decision Experiment. In this experiment we are looking at how stakeholders allocate water resources under water shortages, using three different water management policies. To do this you will take on the role of water managers responsible for the allocation of water. You will be in groups of three that as a whole will represent a river basin, you will either be responsible for the allocation of water in Region A (upstream), Region B (midstream), or Region C (downstream) within that basin. Region A will always allocate first, followed by Region B, and lastly Region C.

Allocation round: Upon the start of an allocation round, you will see a box on the left side of your screen with a total number of available water units. These units will be available to you to allocate to your region's sectors. The sectors in each region are Industry, Agriculture, Municipal, and Environmental Services. Each sector's water demand is shown by the respective number of units that are empty, these demands will vary by sector and region. For every unit of water allocated to a sector you will get a certain point return that you will be able to see at the bottom of your screen. Each of the respective sectors has a different point value that is based on systematic considerations of water demands. Additionally each region gains points from hydropower, the points from hydropower will occur naturally based on the amount of water units that you start with in your inflow box. The more water entering your region, the more points you will generate at the start of your allocation turn. There is one exception to this rule: when water is allocated to the environment it is assumed that it cannot pass through a hydropower station and you thus will not generate those hydropower points.

On the left side of your screen you will see your outflow box, this displays how much water will pass on to the next region. The outflow takes into account how much water you haven't used as well as the varying return flows from your sectors.

Once Region A has allocated the available water units to the respective sectors, click submit at the bottom of your screen, at that time it will be Region B's turn to allocate and once they are done it's Region C's turn.

A number of policies will be tested in this experiment, with a different policy dictating the allocation rules for the entire basin. Each policy will be explained before the start of that round. Additionally there will be varying levels of water units that the basin as a whole will start with.

Unless specified you are not to talk to other participants or look at their screens.

Continue ...

Fig. 1.2. Example experiment interface. Participants had 5 minutes to familiarize themselves with the experiment interface using generic Region X (all the water demands were the same).

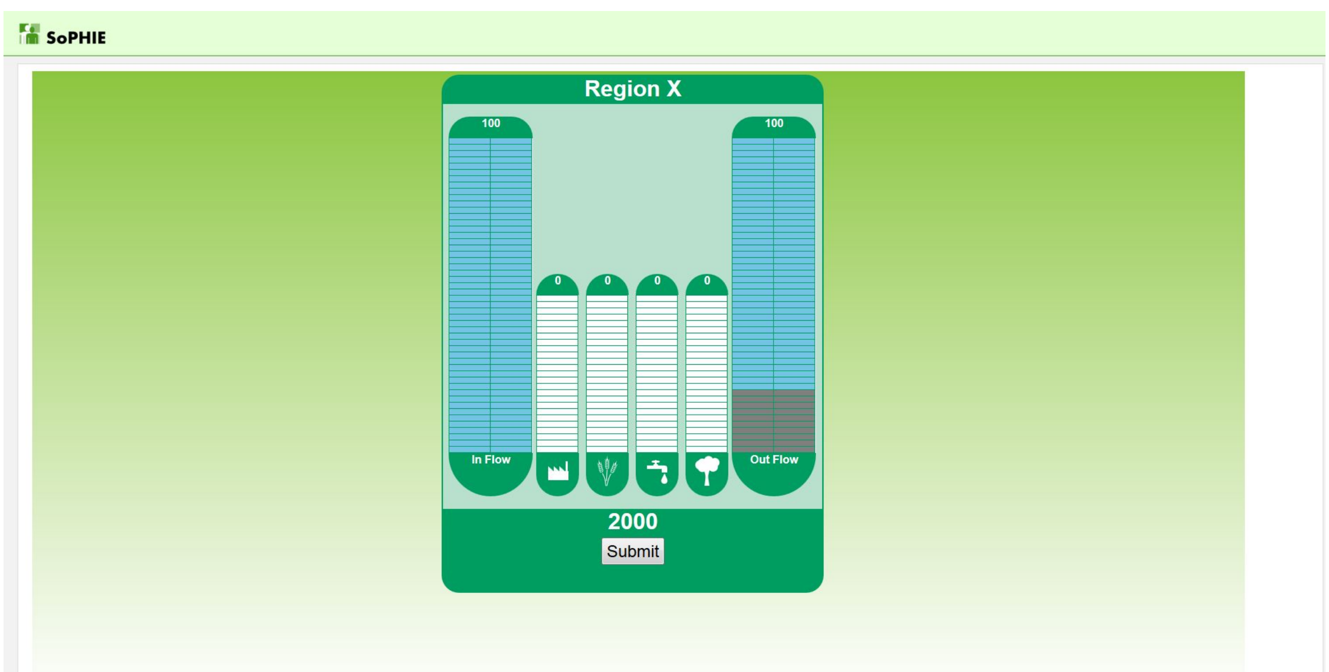


Fig. 1.3. Participants were given instructions for stage one (Policy 1 – status quo—Drier-than-average conditions of today)

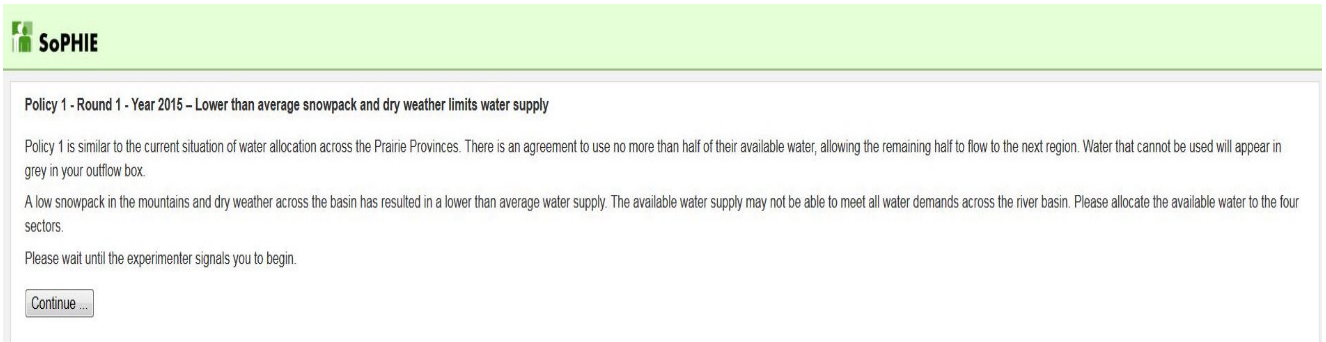


Fig. 1.4. After all participants read the instructions and clicked continue, participants in Region A were prompted to begin their allocations, while Regions B and C were notified to wait. (Note that in the Policy 1 scenario the grey boxes in the outflow box represent the minimum flow of water that must be passed on to the next region.)

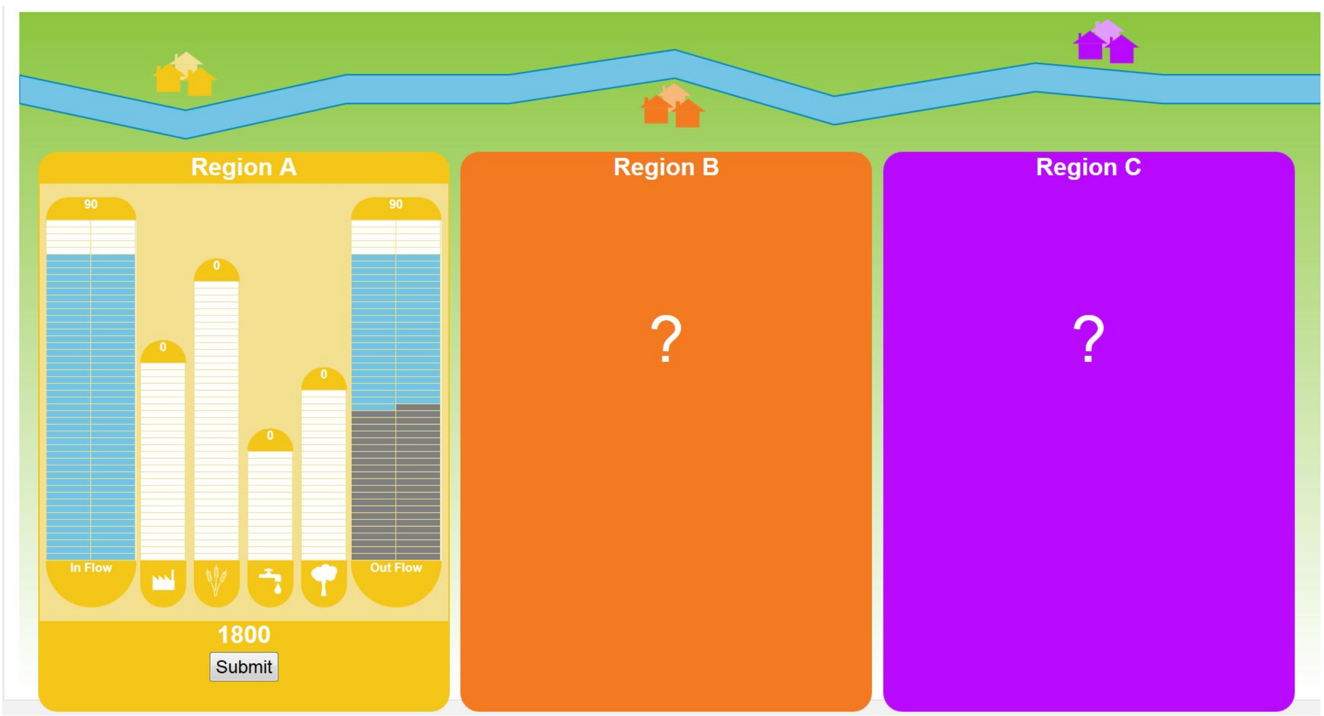


Fig. 1.5. Participants in Region A allocated their water units. When satisfied with their allocations after two minutes, participants in Region A were instructed to click Submit.

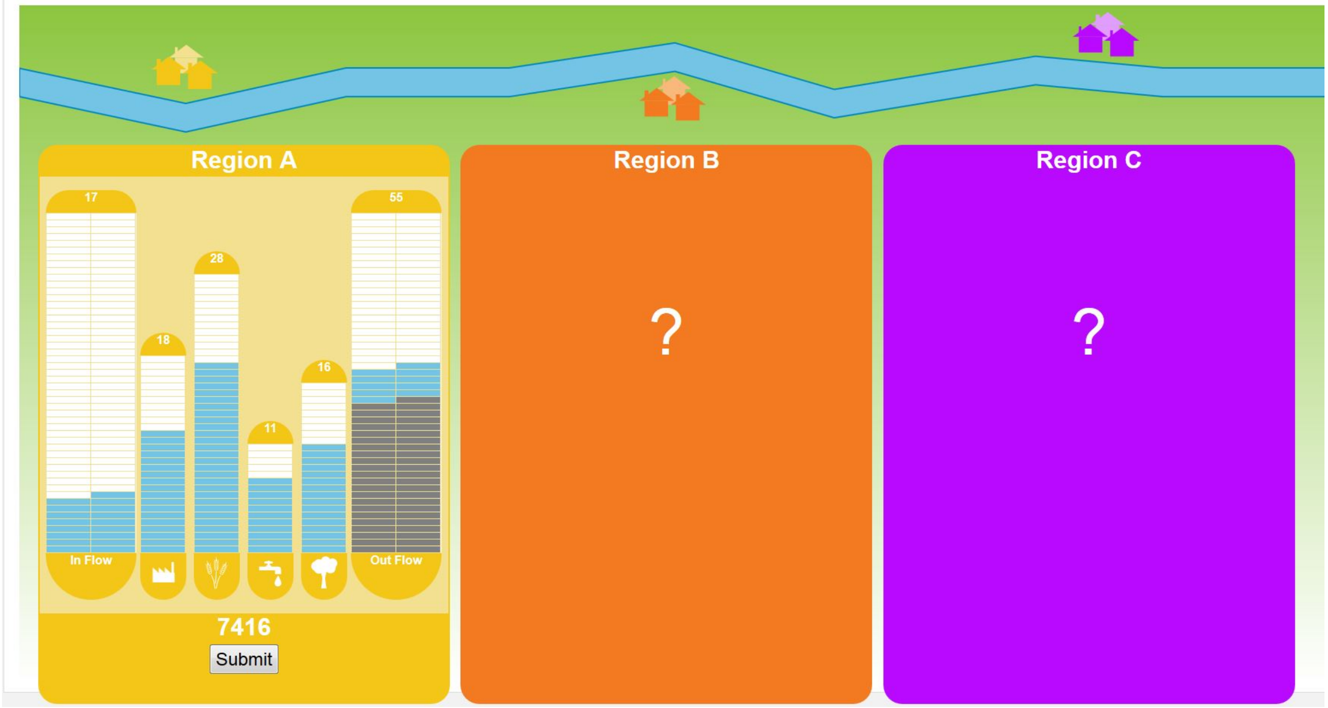


Fig. 1.6. Participants in Region B were then prompted to begin their allocations, while Regions A and C were notified to wait.

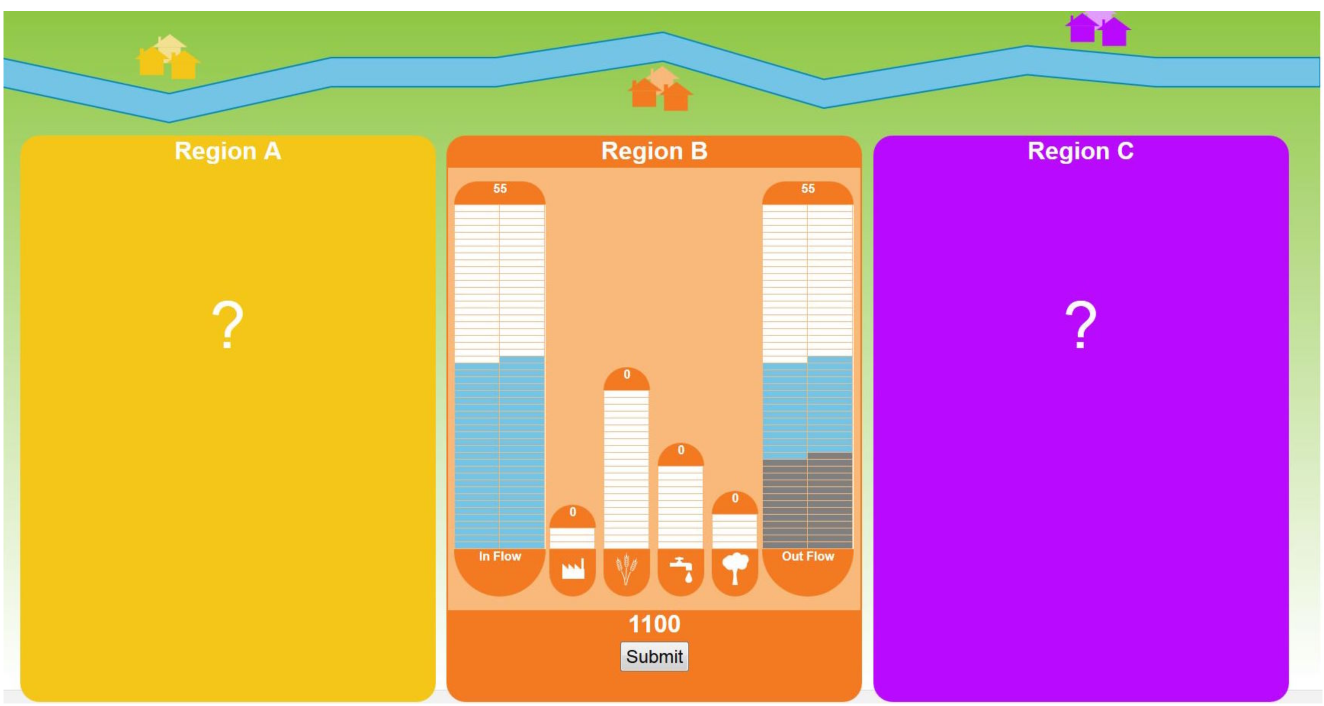


Fig. 1.7. Participants in Region B allocated their water units. When satisfied with their allocations after two minutes, participants in Region B were instructed to click Submit.

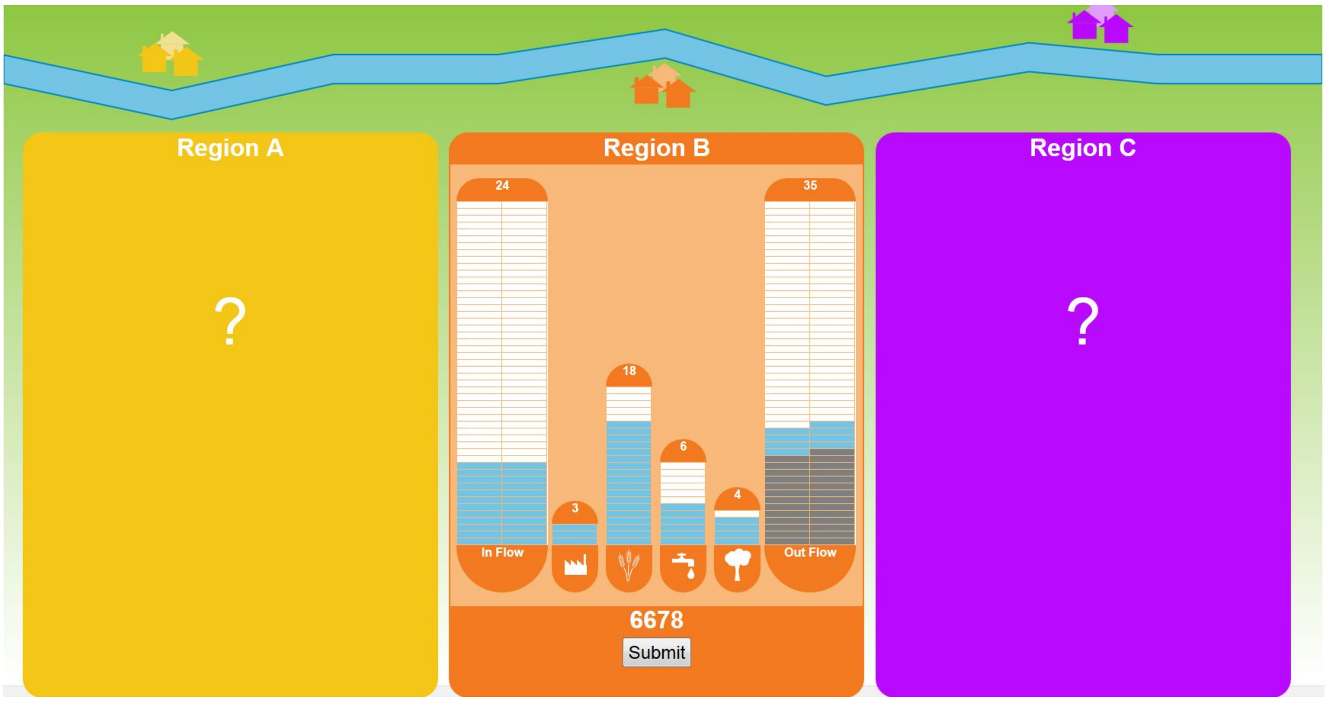


Fig. 1.8. Participants in Region C were then prompted to begin their allocations, while Regions A and B were notified to wait.

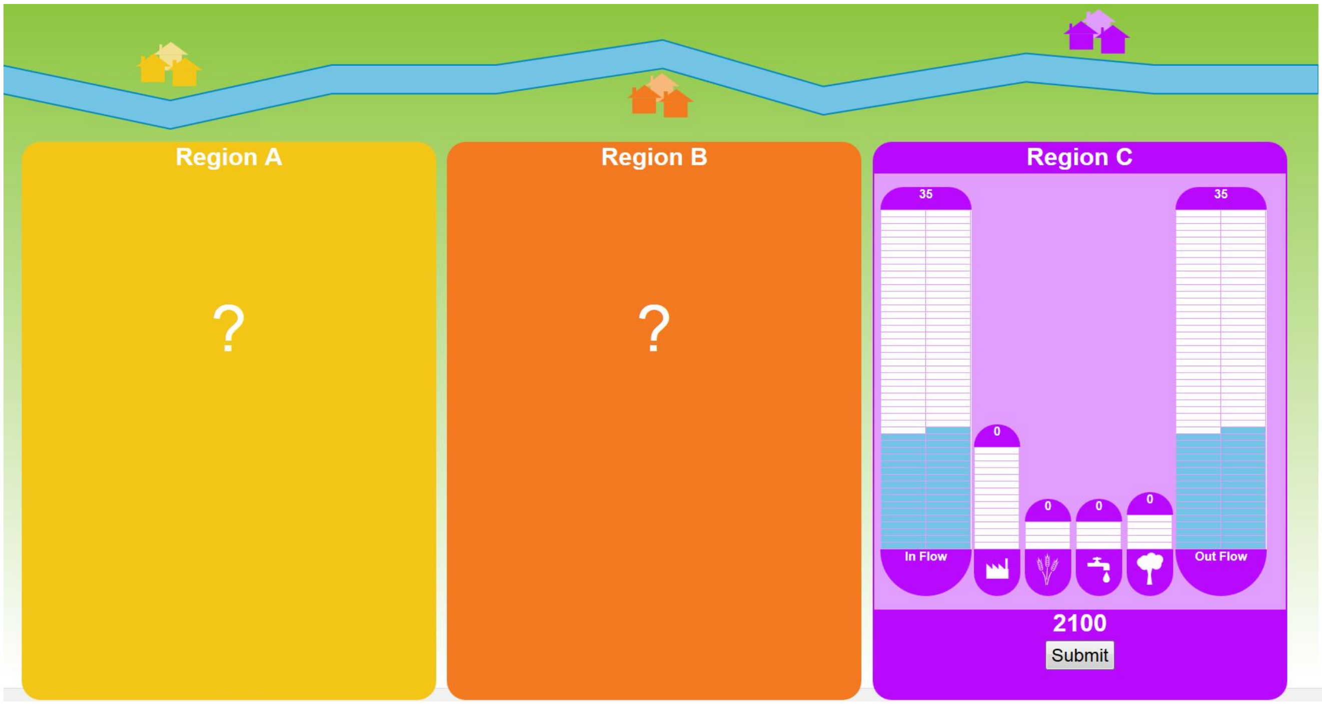


Fig. 1.9. Participants in Region C allocated their water units. When satisfied with their allocations after two minutes, participants in Region C were instructed to click Submit.

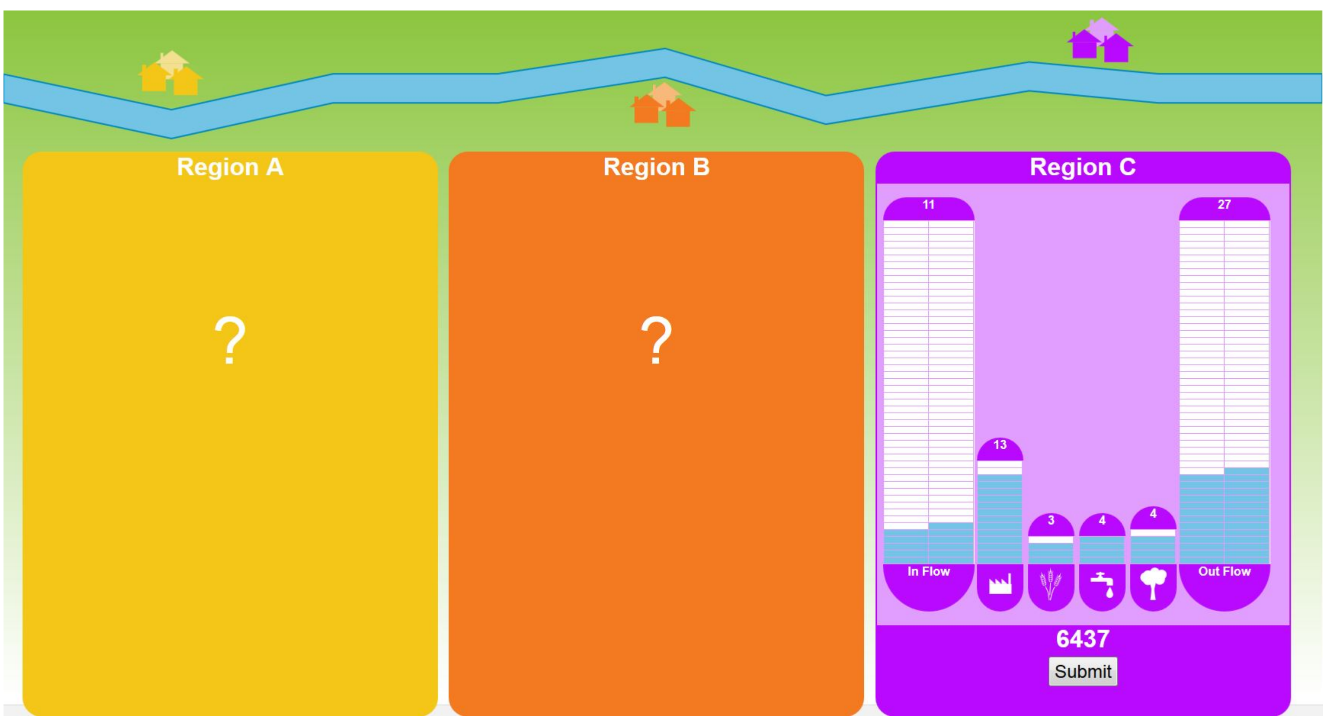


Fig. 2.0. Participants were given instructions for stage two (Policy 1 – status quo—Severe drought conditions).

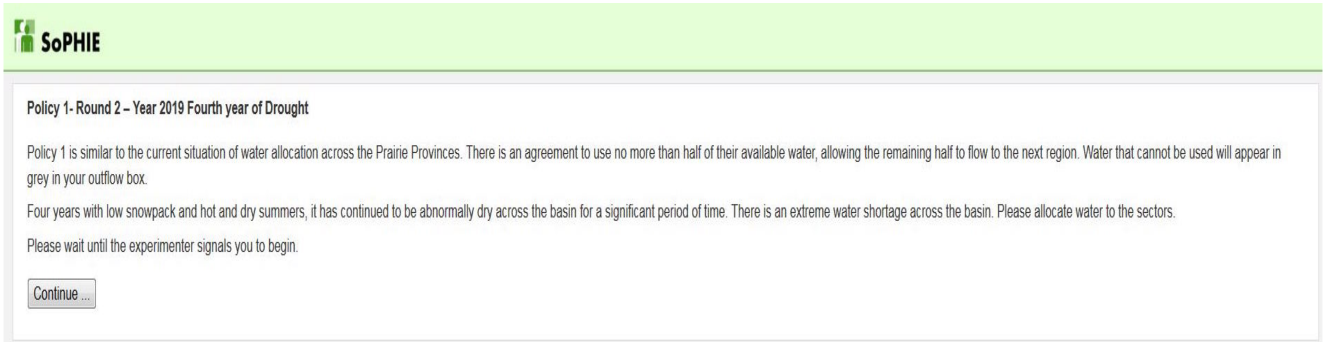


Fig. 2.1. After all participants read the instructions and clicked continue, participants in Region A were prompted to begin their allocations, while Regions B and C were notified to wait. (Note that in the Policy 1 scenario the grey boxes in the outflow box represent the minimum flow of water that must be passed on to the next region.)

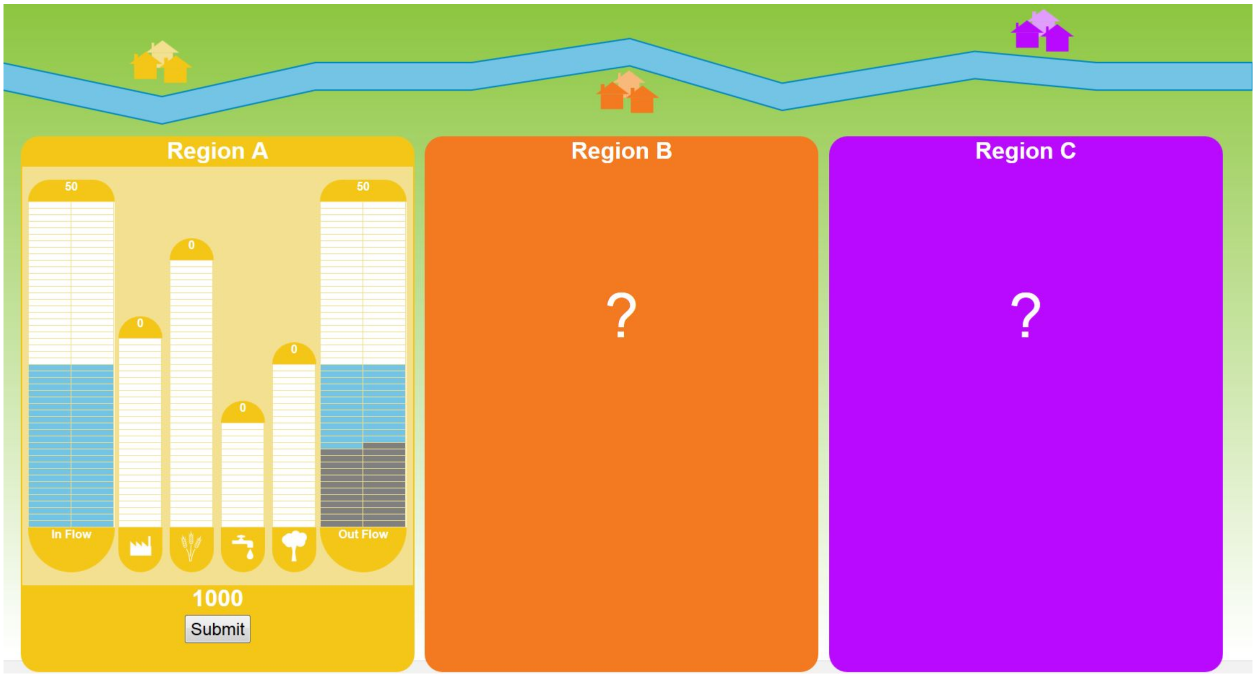


Fig. 2.2. Participants in Region A allocated their water units. When satisfied with their allocations after two minutes, participants in Region A were instructed to click Submit.

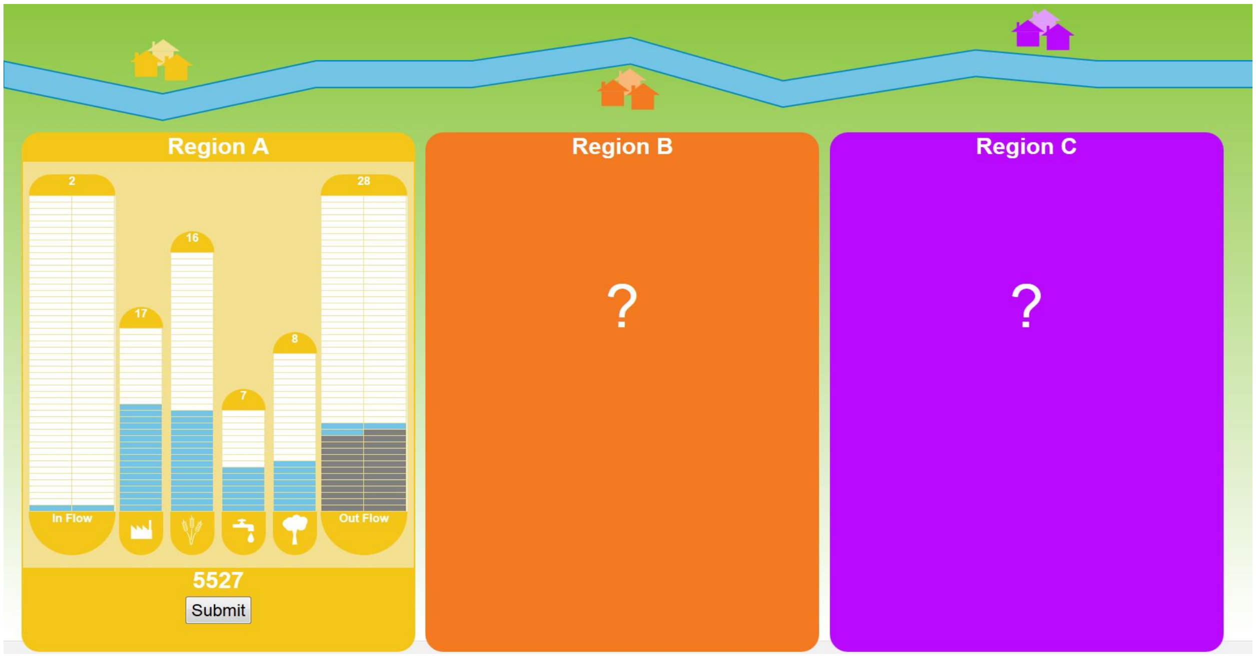


Fig. 2.3. Participants in Region B were then prompted to begin their allocations, while Regions A and C were notified to wait.

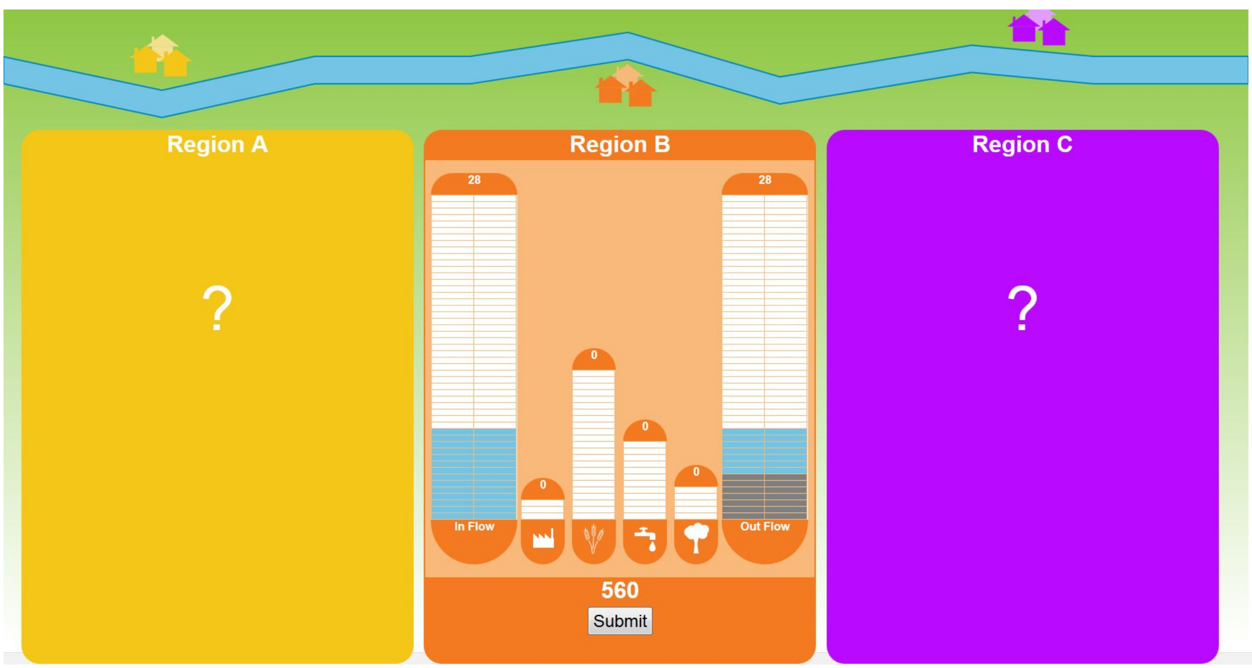


Fig. 2.4. Participants in Region B allocated their water units. When satisfied with their allocations after two minutes, participants in Region B were instructed to click Submit.

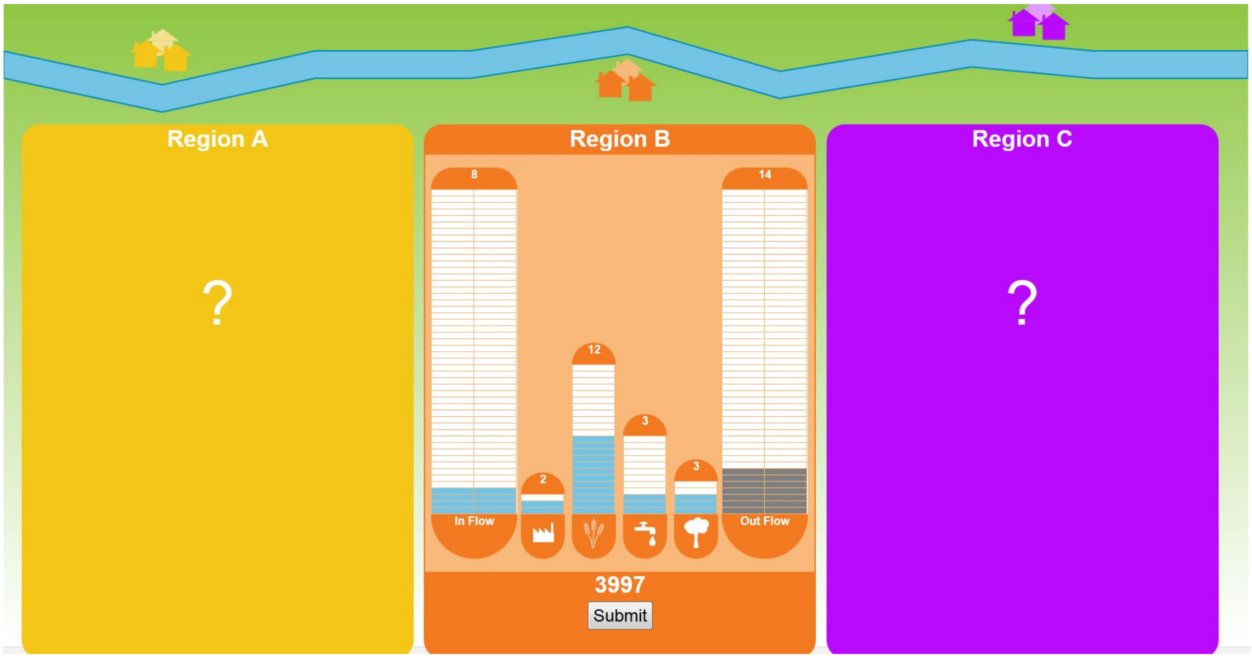


Fig. 2.5. Participants in Region C were then prompted to begin their allocations, while Regions A and B were notified to wait.

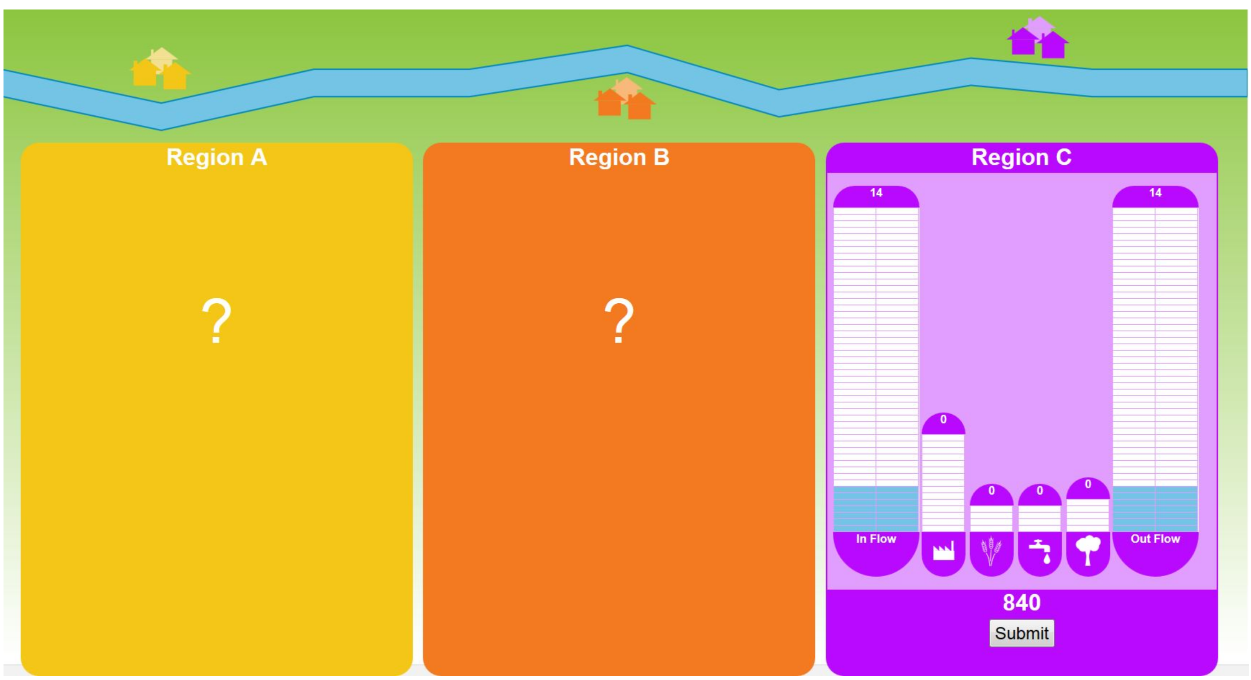


Fig. 2.6. Participants in Region C allocated their water units. When satisfied with their allocations after two minutes, participants in Region C were instructed to click Submit.

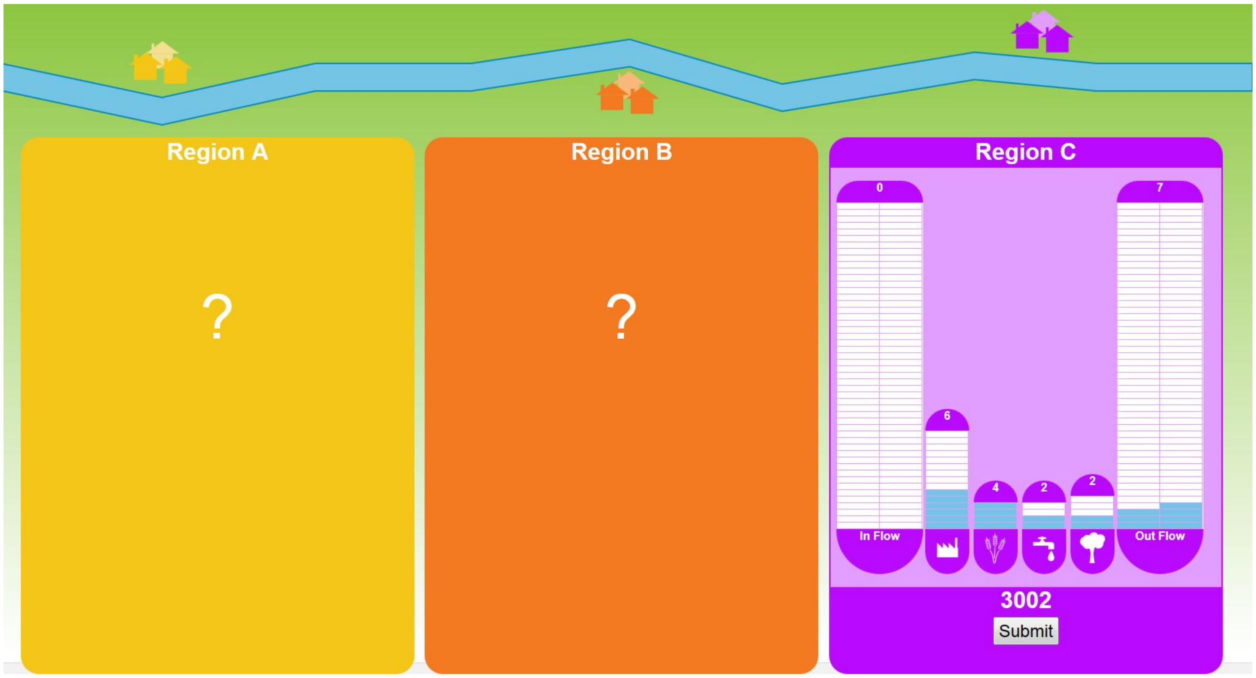


Fig. 3.0. Participants were given instructions for stage three (Policy 2 – no rule set—Drier-than-average conditions of today).

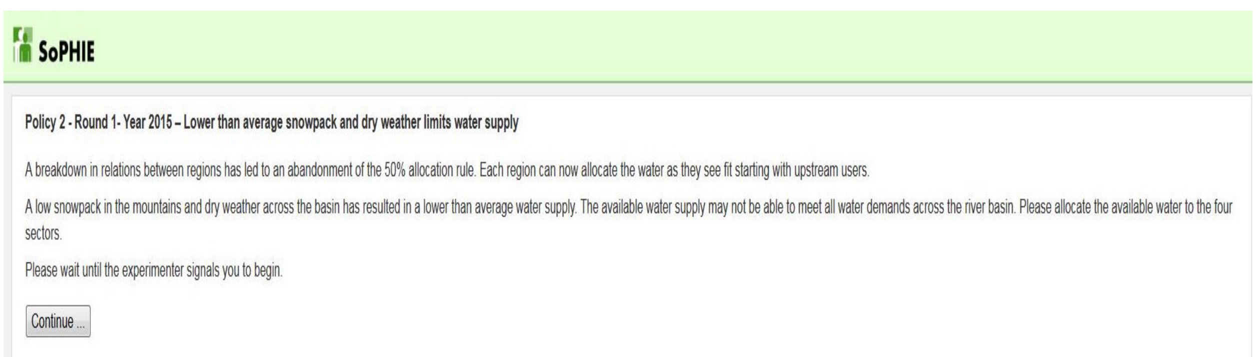


Fig. 3.1. After all participants read the instructions and clicked continue, participants in Region A were prompted to begin their allocations, while Regions B and C were notified to wait.

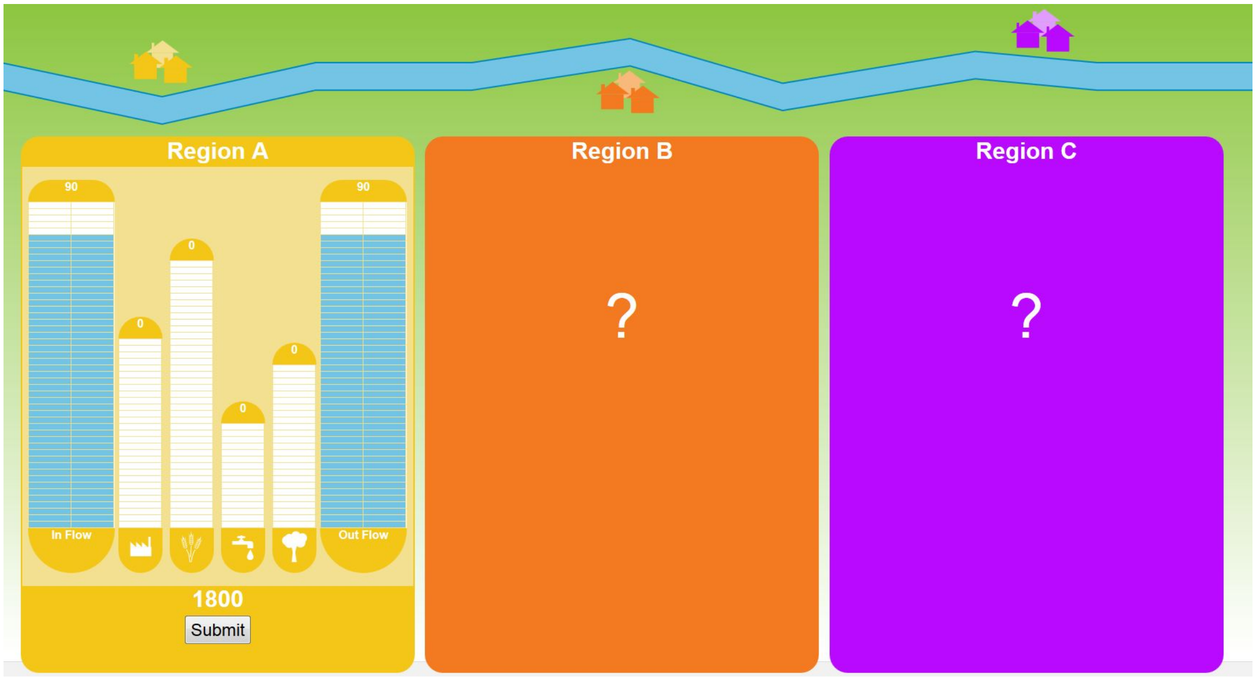


Fig. 3.2. Participants in Region A allocated their water units. When satisfied with their allocations after two minutes, participants in Region A were instructed to click Submit.

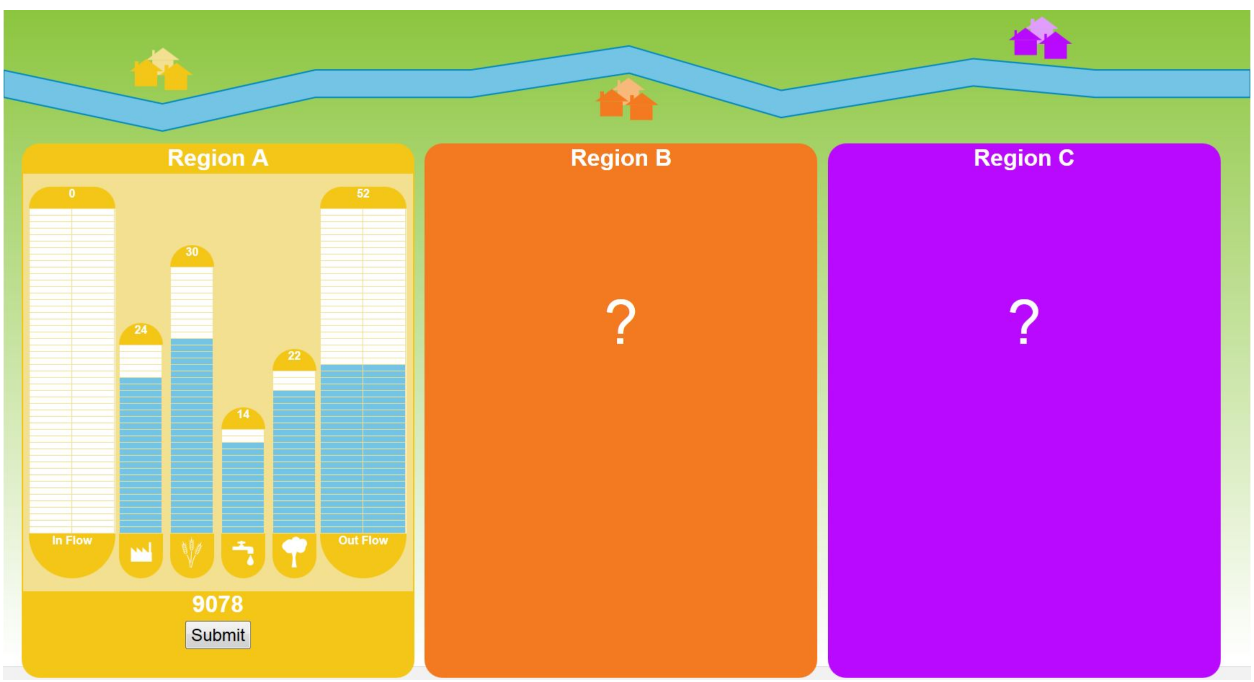


Fig. 3.3. Participants in Region B were then prompted to begin their allocations, while Regions A and C were notified to wait.

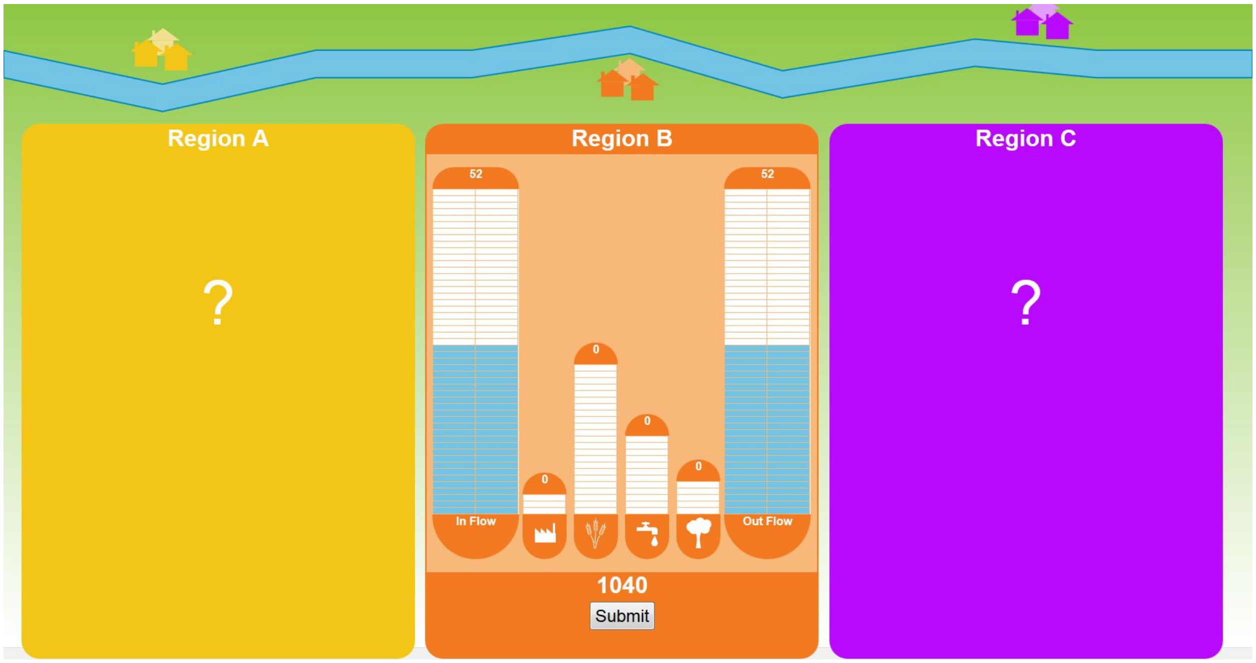


Fig. 3.4. Participants in Region B allocated their water units. When satisfied with their allocations after two minutes, participants in Region B were instructed to click Submit.

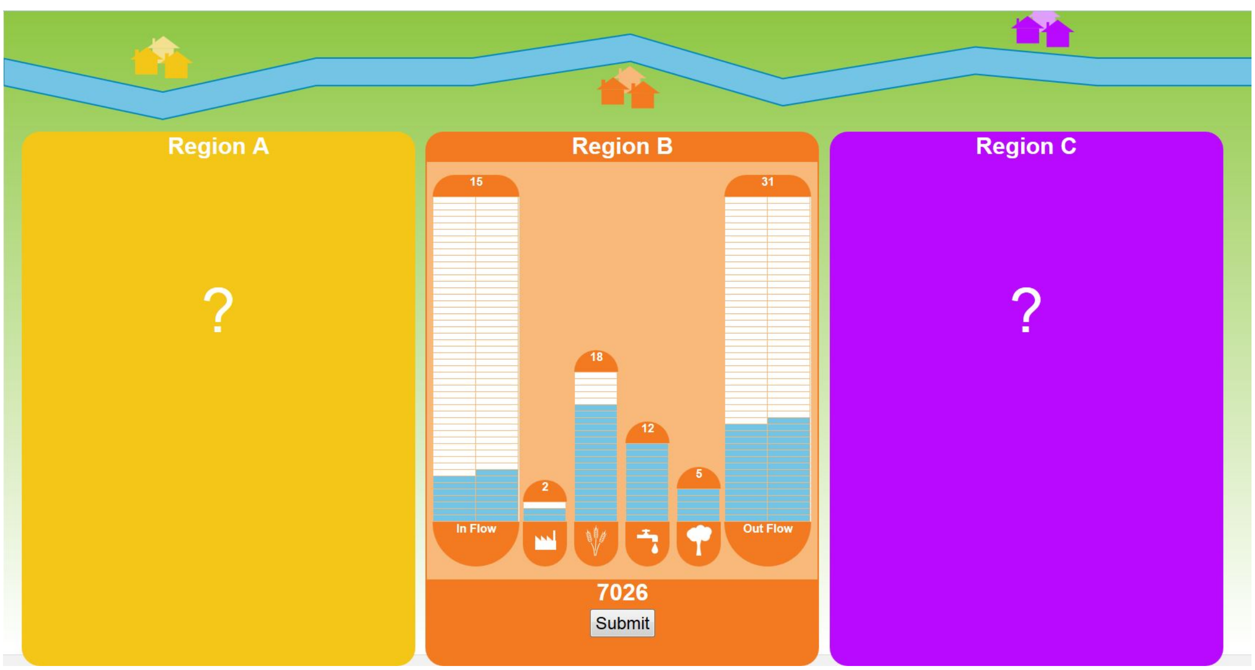


Fig. 3.5. Participants in Region C were then prompted to begin their allocations, while Regions A and B were notified to wait.

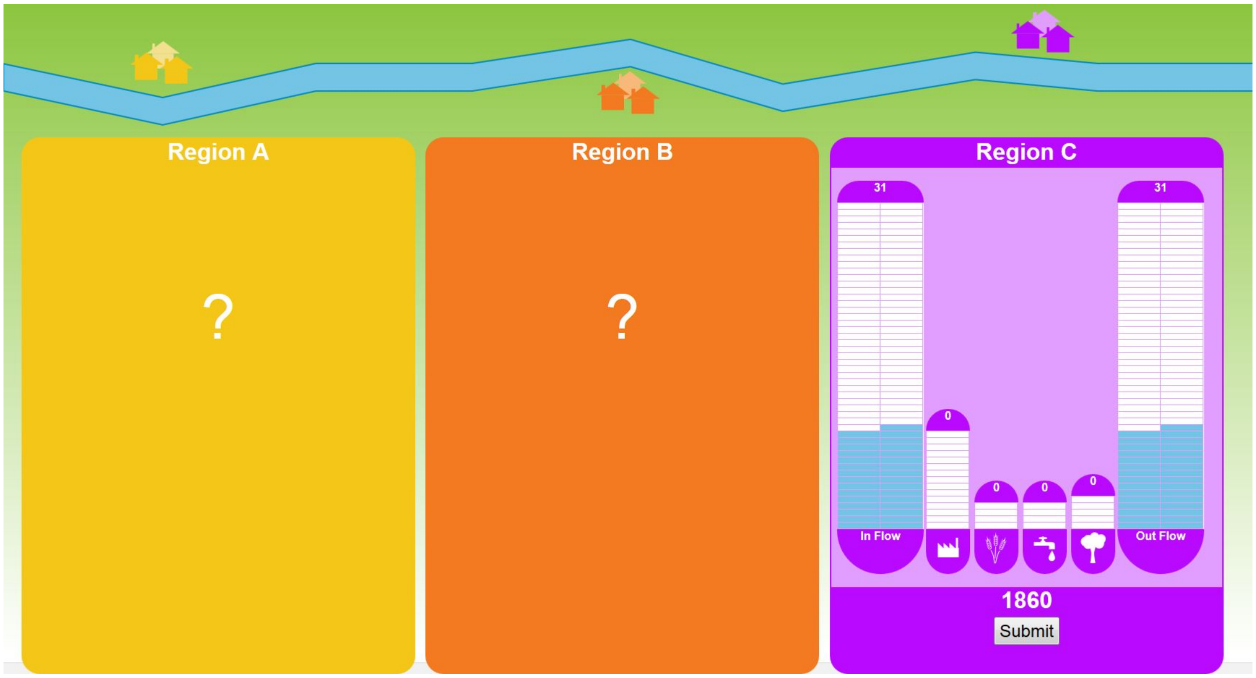


Fig. 3.6. Participants in Region C allocated their water units. When satisfied with their allocations after two minutes, participants in Region C were instructed to click Submit.

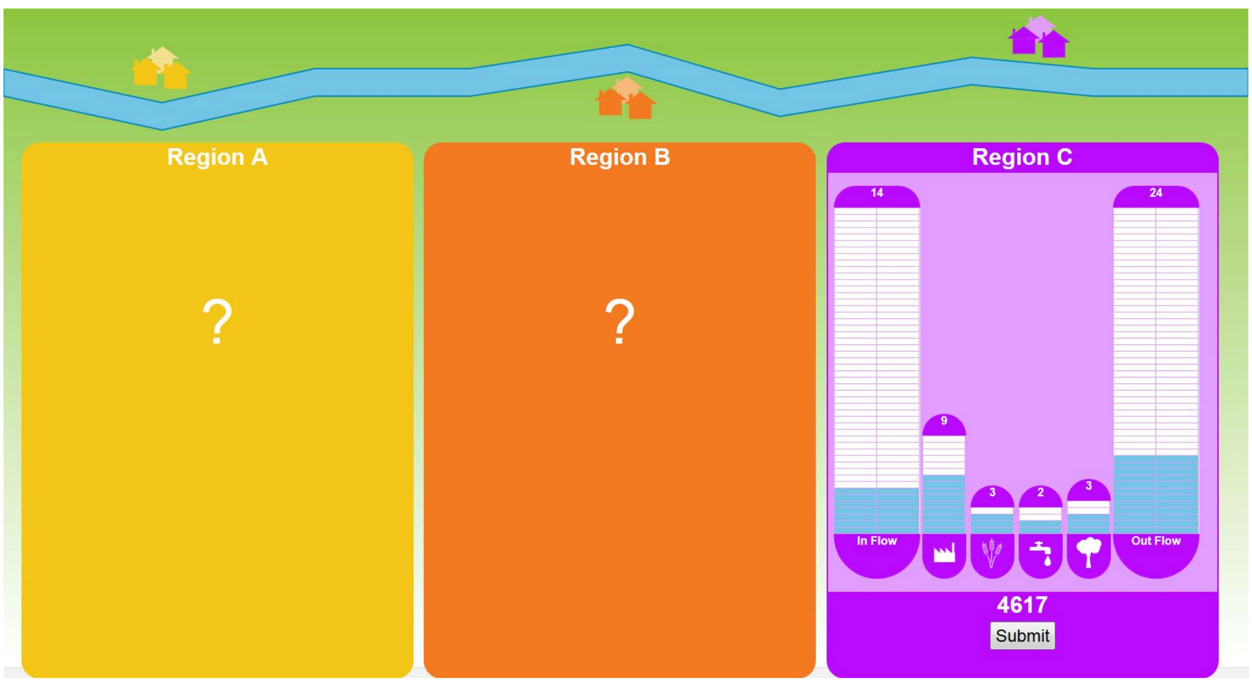


Fig. 4.0. Participants were given instructions for stage four (Policy 2 – no rule set—Severe drought conditions).

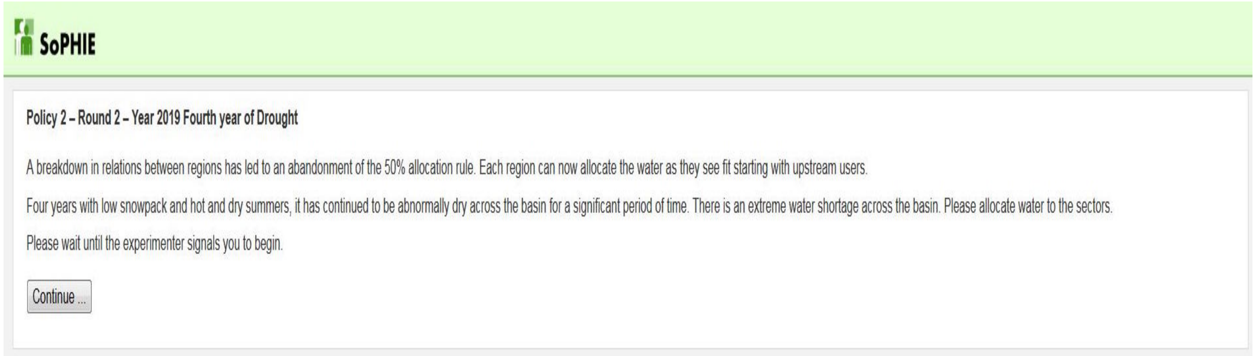


Fig. 4.1. After all participants read the instructions and clicked continue, participants in Region A were prompted to begin their allocations, while Regions B and C were notified to wait.

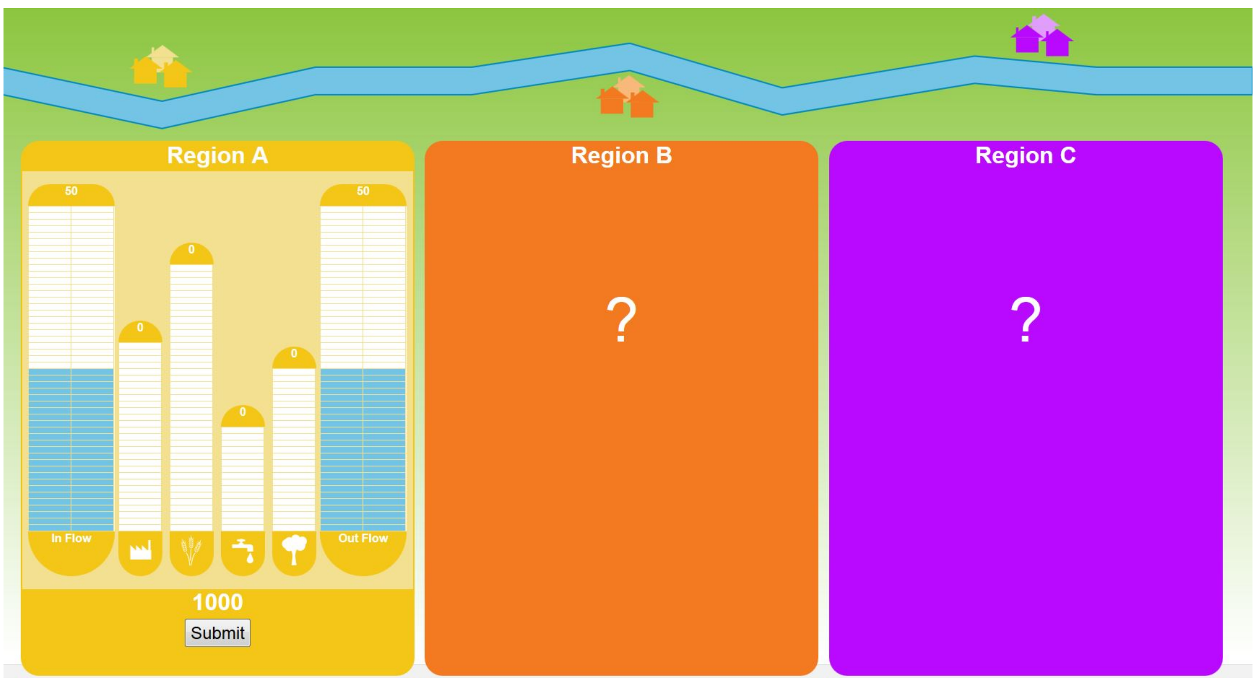


Fig. 4.2. Participants in Region A allocated their water units. When satisfied with their allocations after two minutes, participants in Region A were instructed to click Submit.

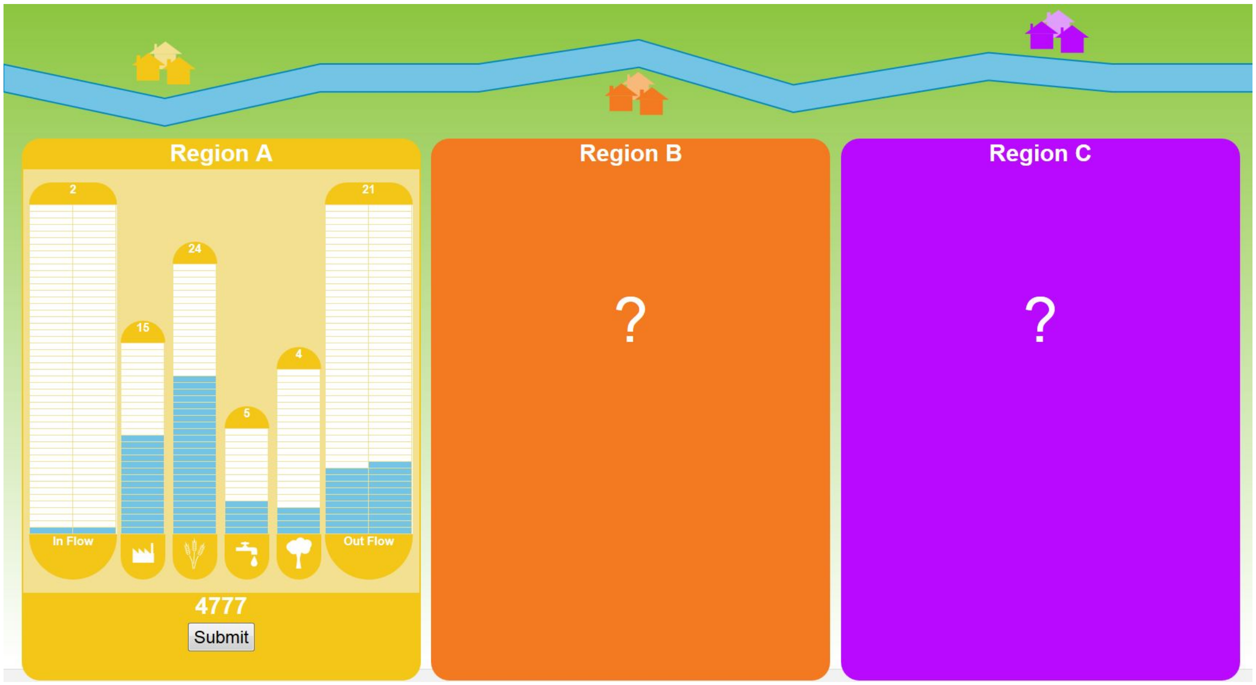


Fig. 4.3. Participants in Region B were then prompted to begin their allocations, while Regions A and C were notified to wait.

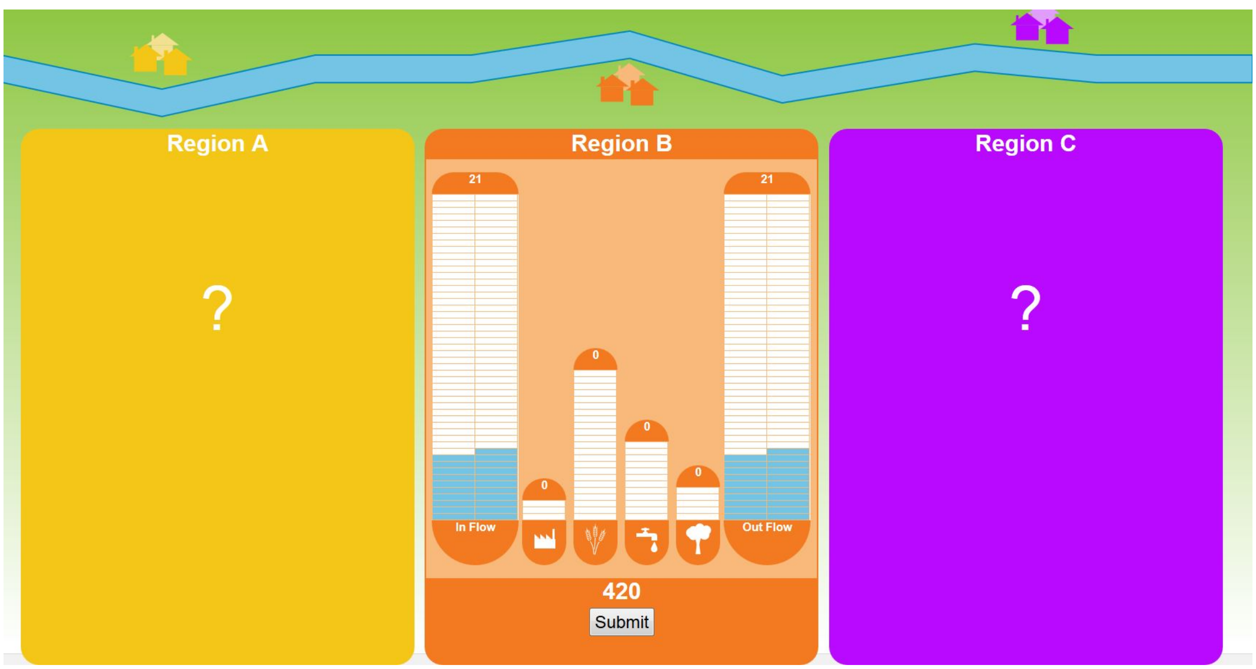


Fig. 4.4. Participants in Region B allocated their water units. When satisfied with their allocations after two minutes, participants in Region B were instructed to click Submit.

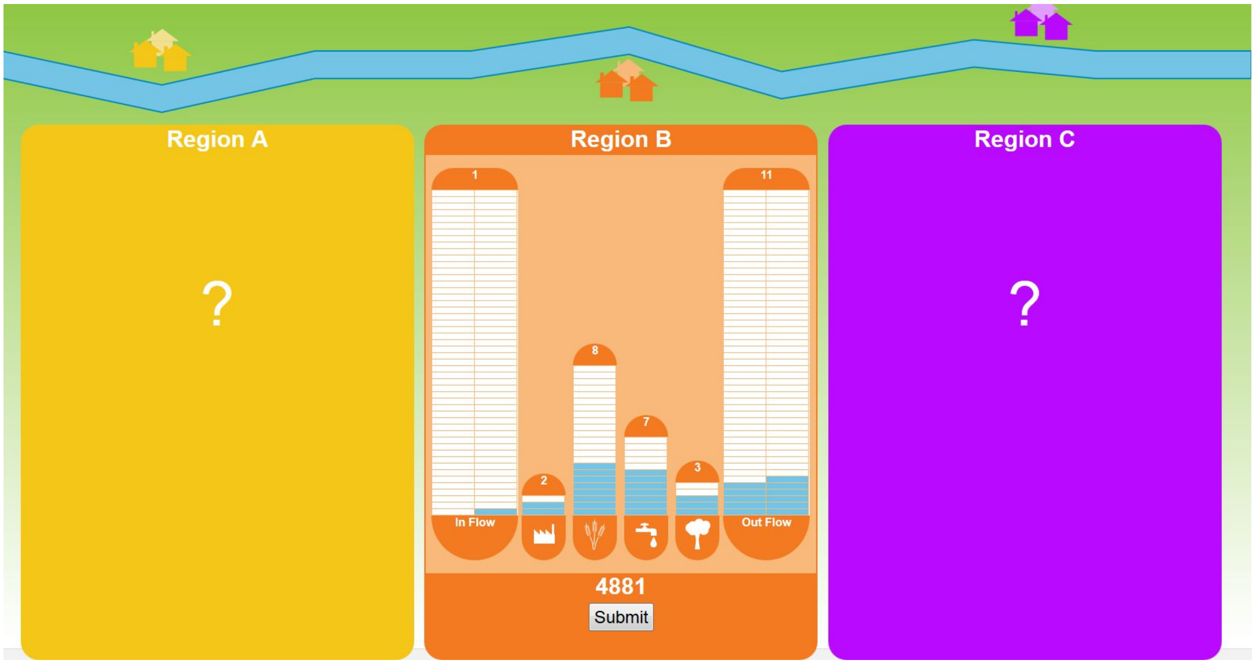


Fig. 4.5. Participants in Region C were then prompted to begin their allocations, while Regions A and B were notified to wait.

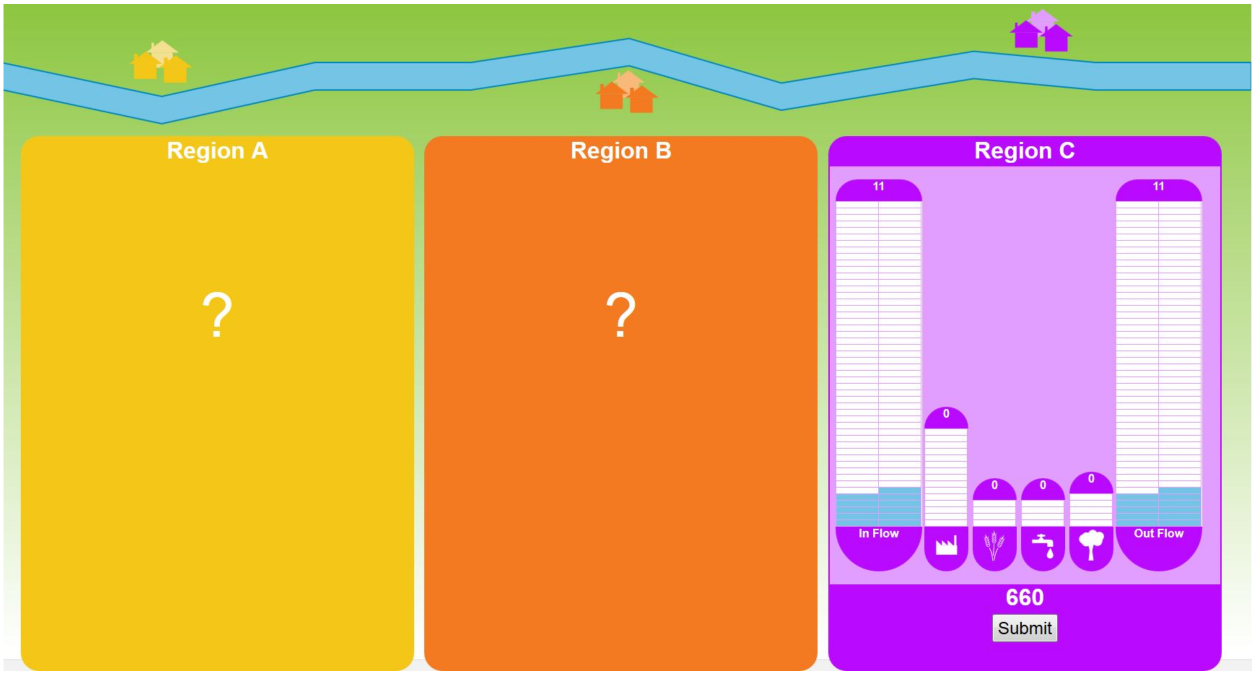


Fig. 4.6. Participants in Region C allocated their water units. When satisfied with their allocations after two minutes, participants in Region C were instructed to click Submit.

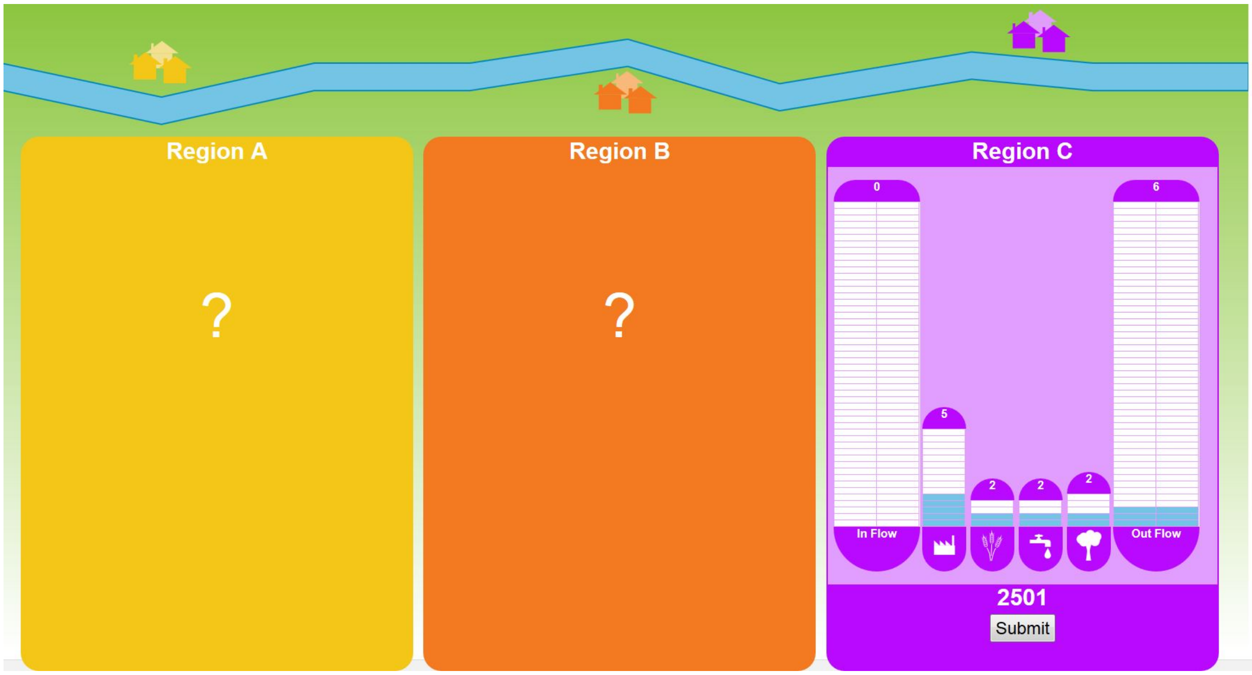


Fig. 5.0. Participants were given instructions for stage five (Policy 3 – shared risk—Drier-than-average conditions of today).

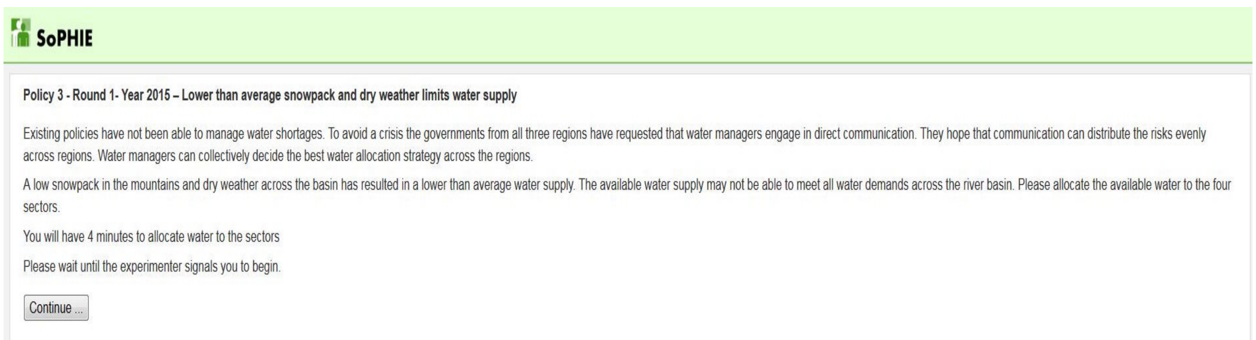


Fig. 5.1. After all participants read the instructions and clicked continue, participants in Region A were prompted to begin their allocations, while Regions B and C were notified to wait.

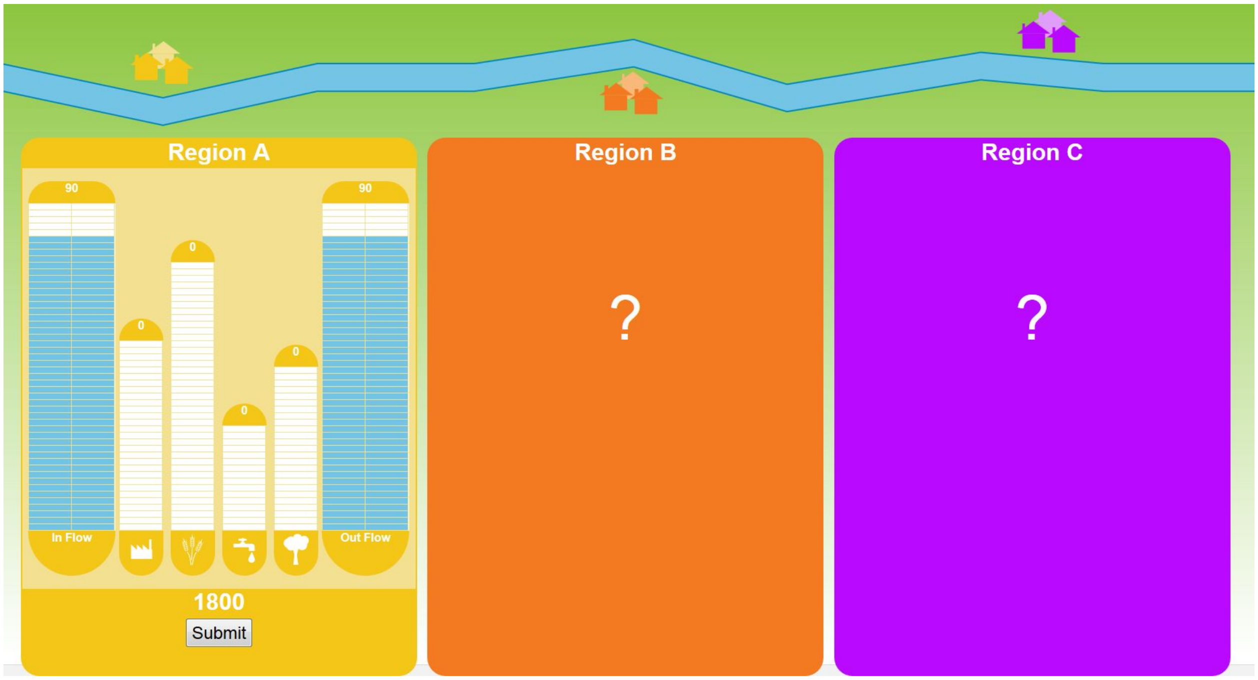


Fig. 5.2. Participants in Region A allocated their water units. When satisfied with their allocations after two minutes, participants in Region A were instructed to click Submit.

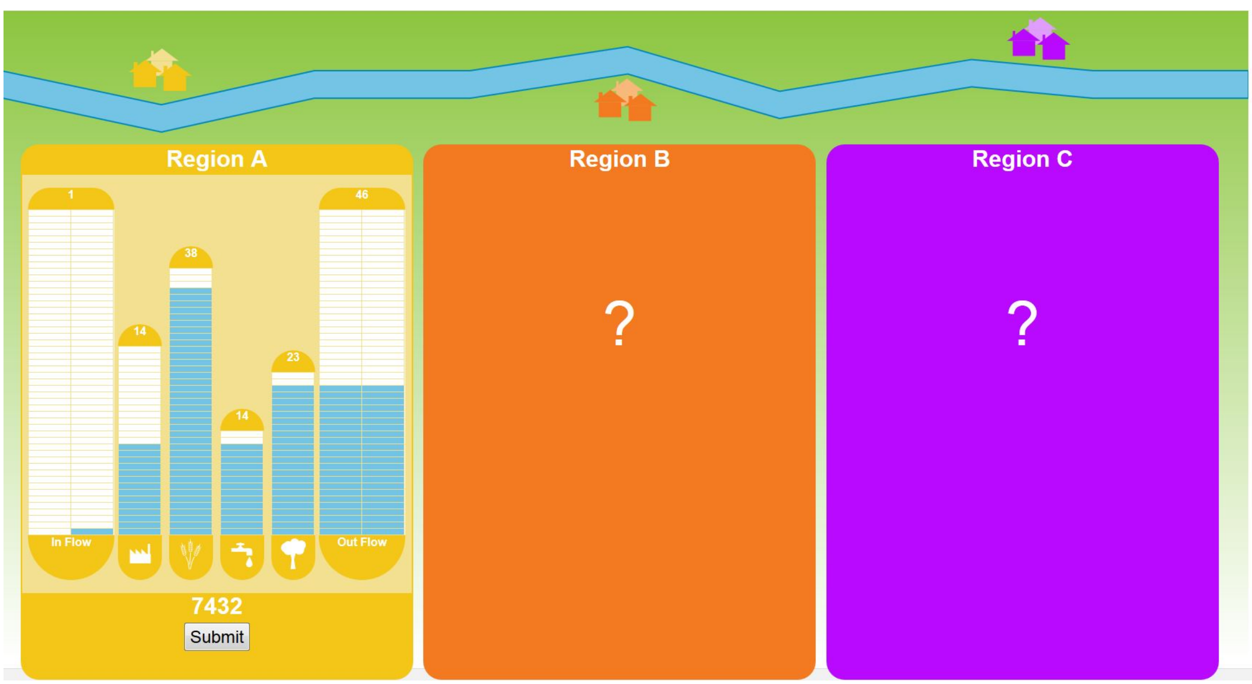


Fig. 5.3. Participants in Region B were then prompted to begin their allocations, while Regions A and C were notified to wait.

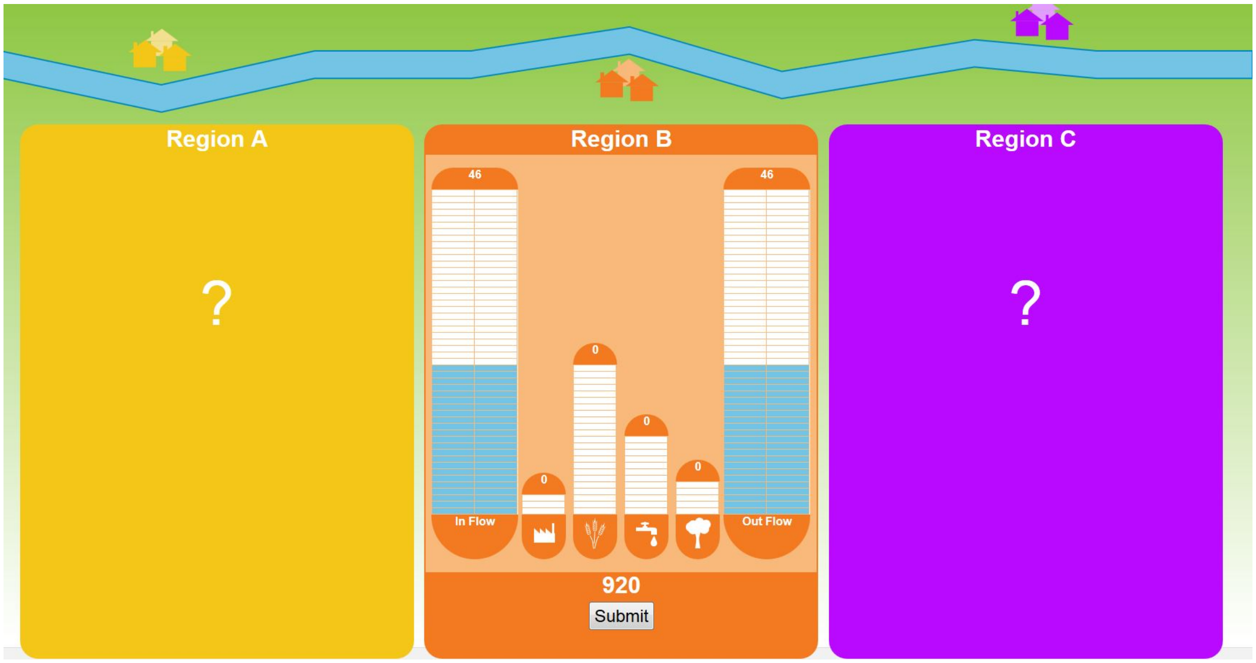


Fig. 5.4. Participants in Region B allocated their water units. When satisfied with their allocations after two minutes, participants in Region B were instructed to click Submit.

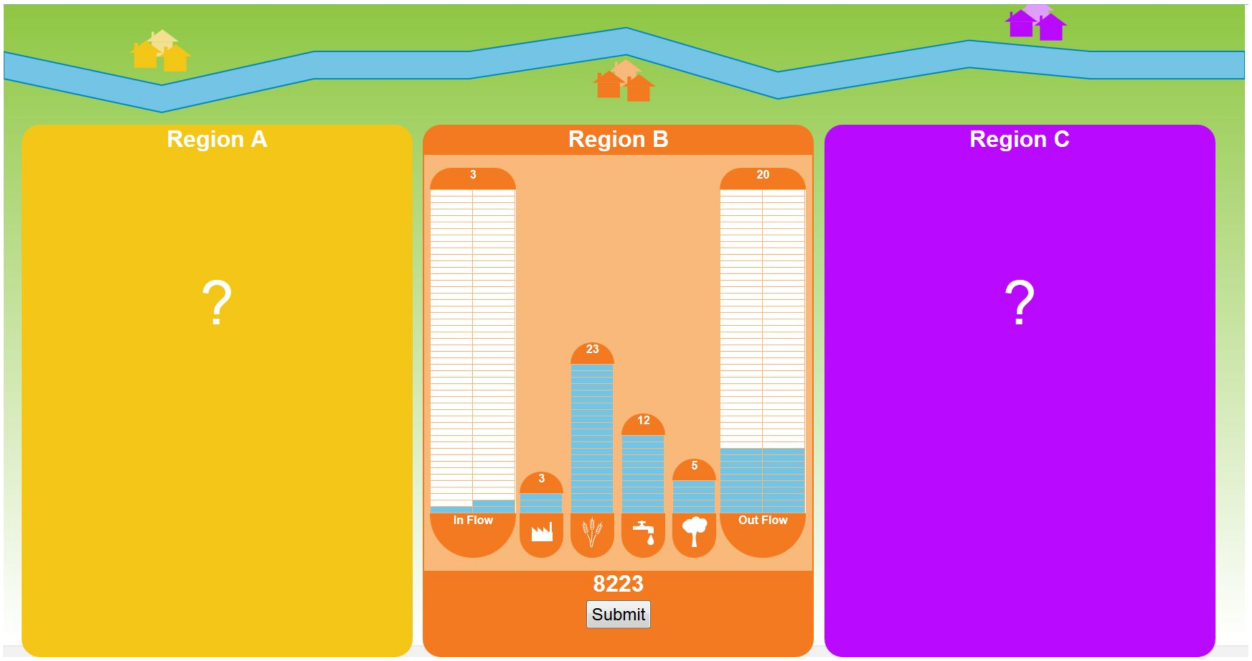


Fig. 5.5. Participants in Region C were then prompted to begin their allocations, while Regions A and B were notified to wait.

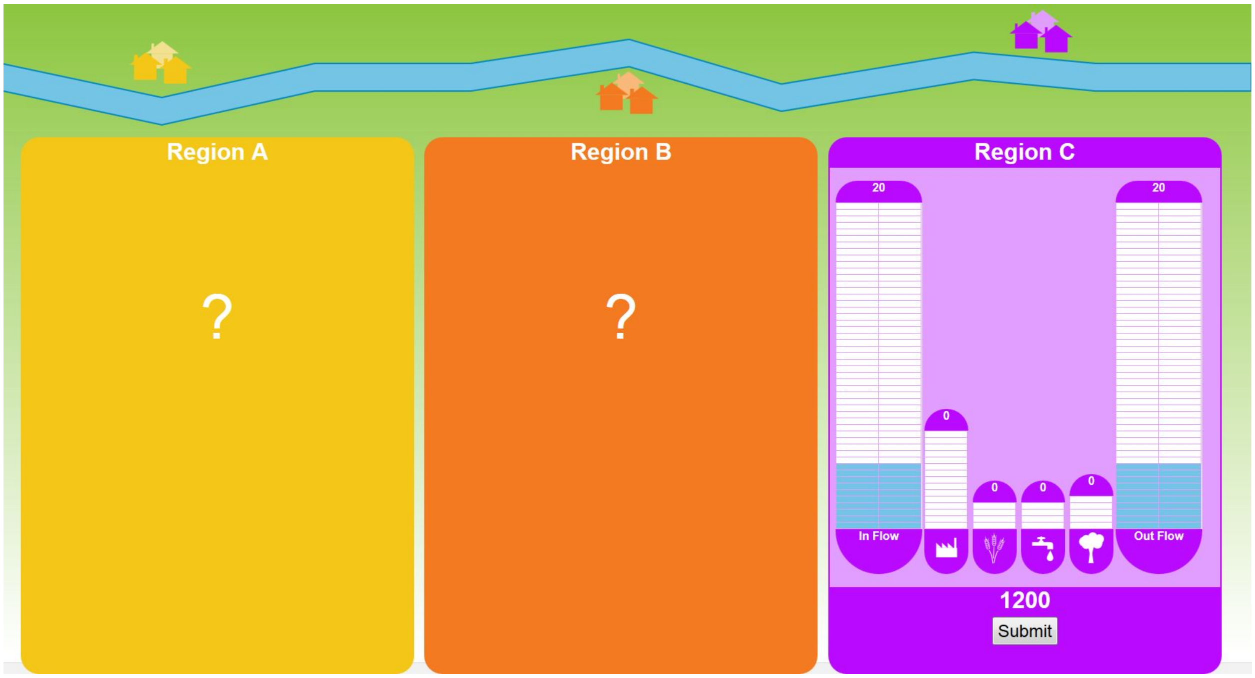


Fig. 5.6. Participants in Region C allocated their water units. When satisfied with their allocations after two minutes, participants in Region C were instructed to click Submit.

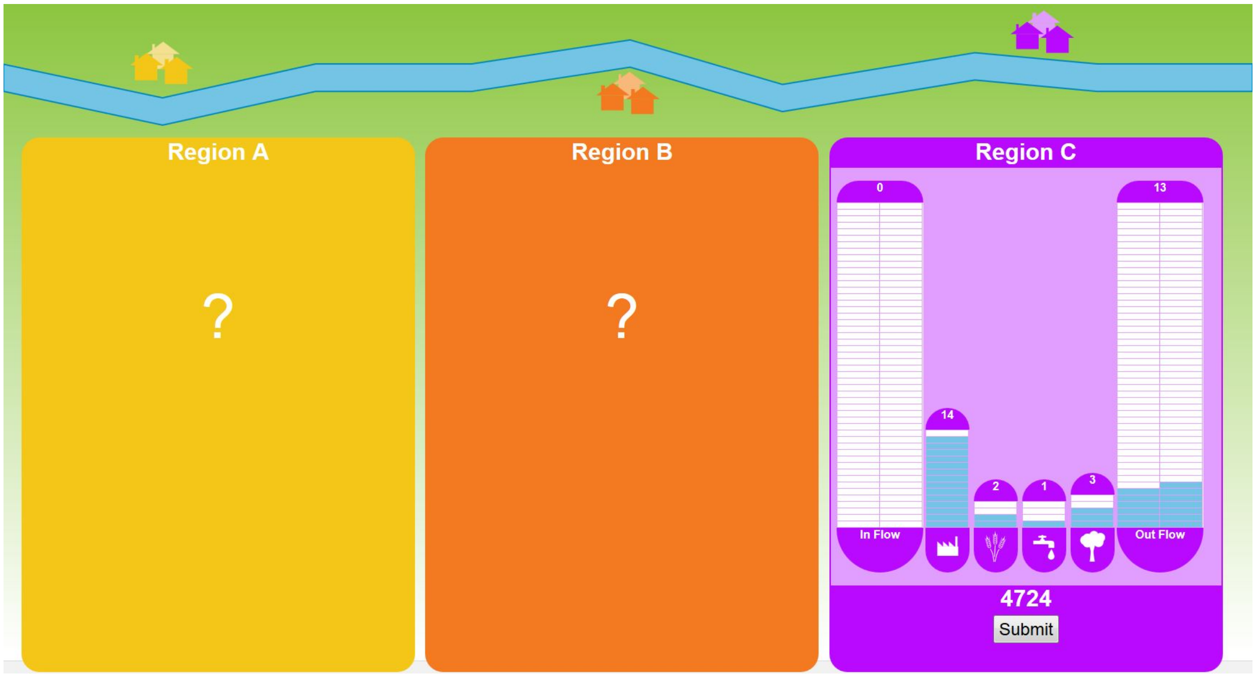


Fig. 6.0. Participants were given instructions for stage six (Policy 3 – shared risk—Severe drought conditions).

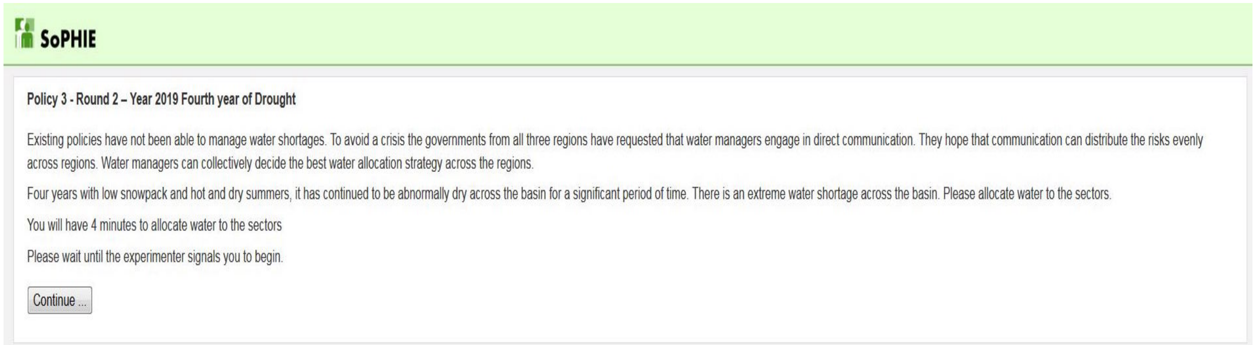


Fig. 6.1. After all participants read the instructions and clicked continue, participants in Region A were prompted to begin their allocations, while Regions B and C were notified to wait.

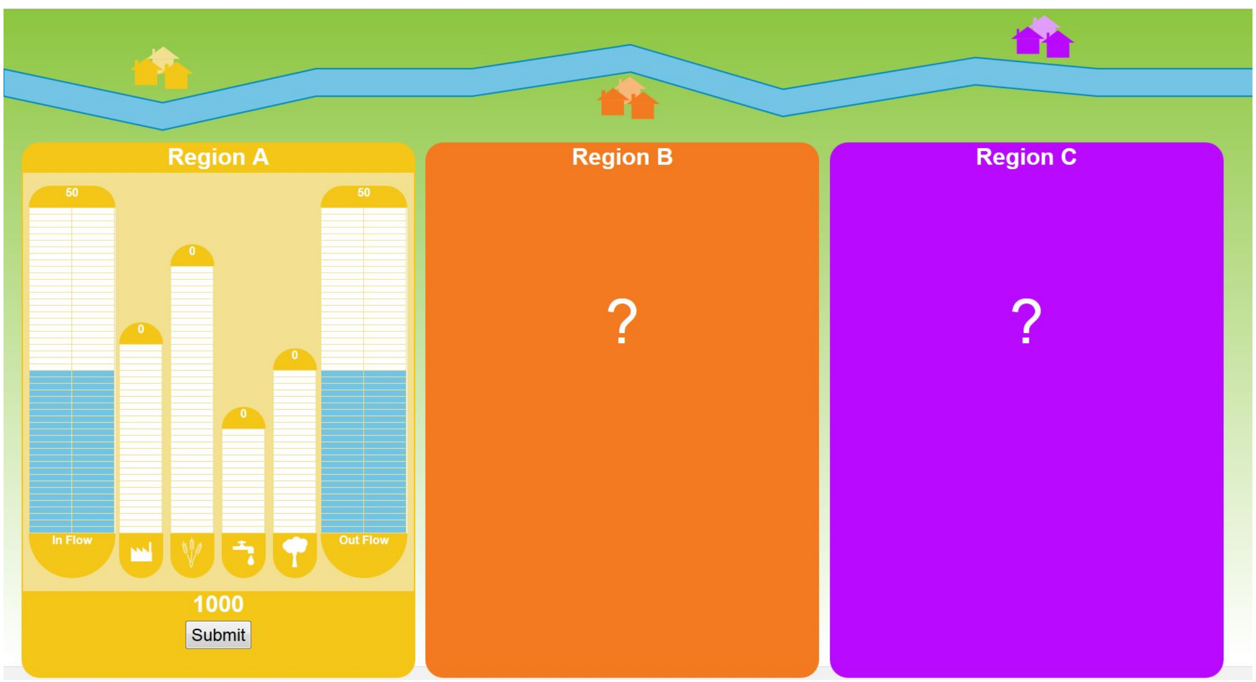


Fig. 6.2. Participants in Region A allocated their water units. When satisfied with their allocations after two minutes, participants in Region A were instructed to click Submit.

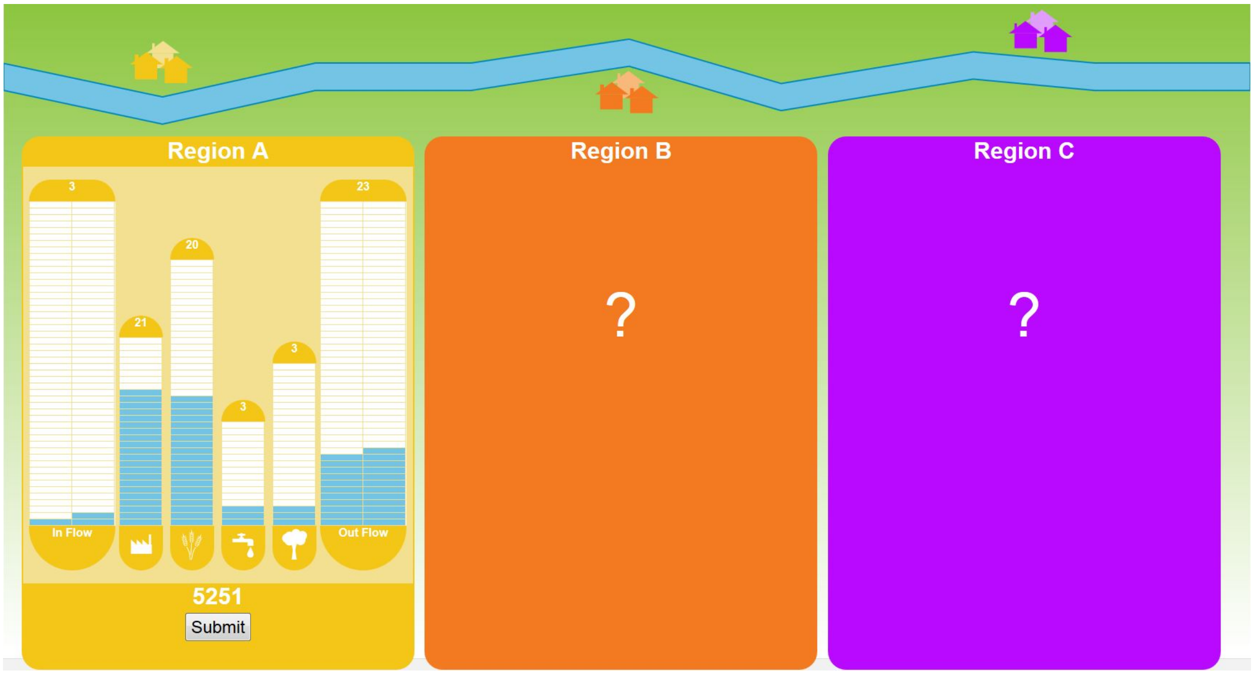


Fig. 6.3. Participants in Region B were then prompted to begin their allocations, while Regions A and C were notified to wait.

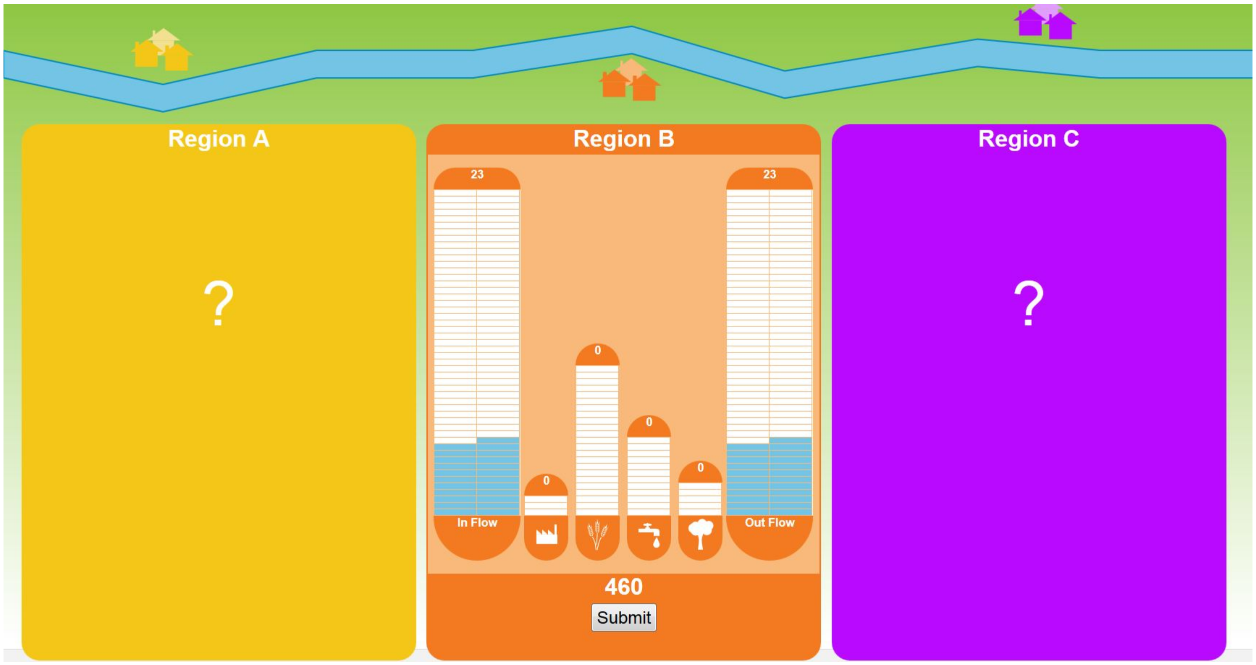


Fig. 6.4. Participants in Region B allocated their water units. When satisfied with their allocations after two minutes, participants in Region B were instructed to click Submit.

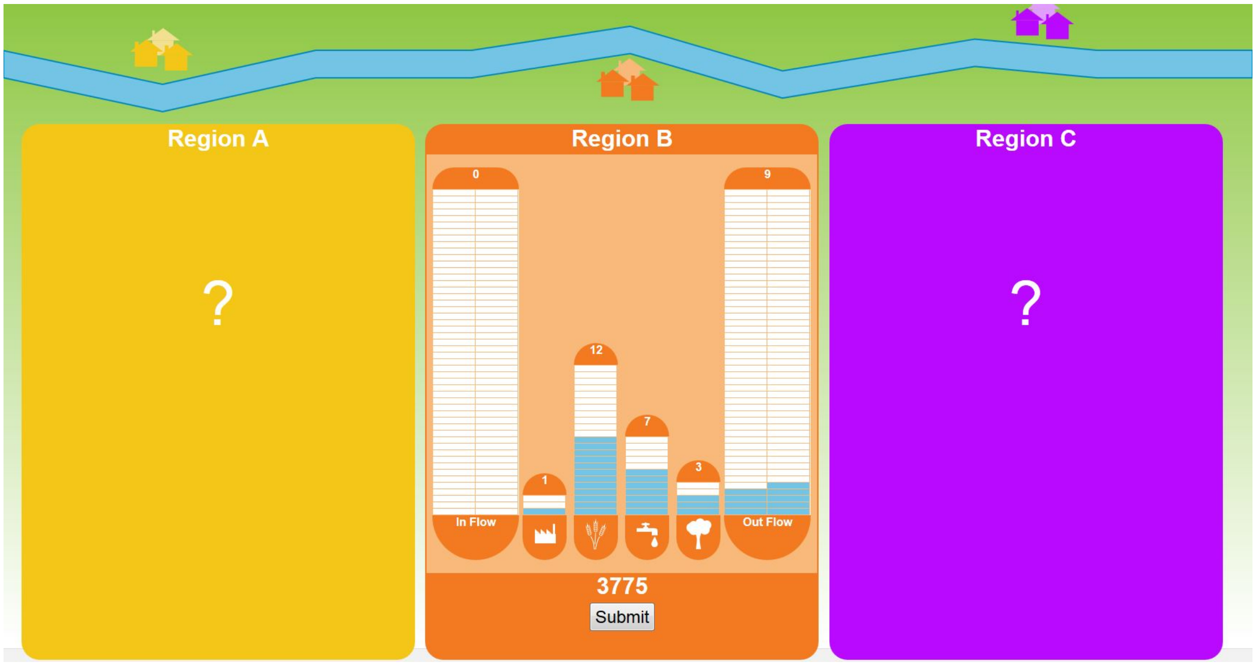


Fig. 6.5. Participants in Region C were then prompted to begin their allocations, while Regions A and B were notified to wait.

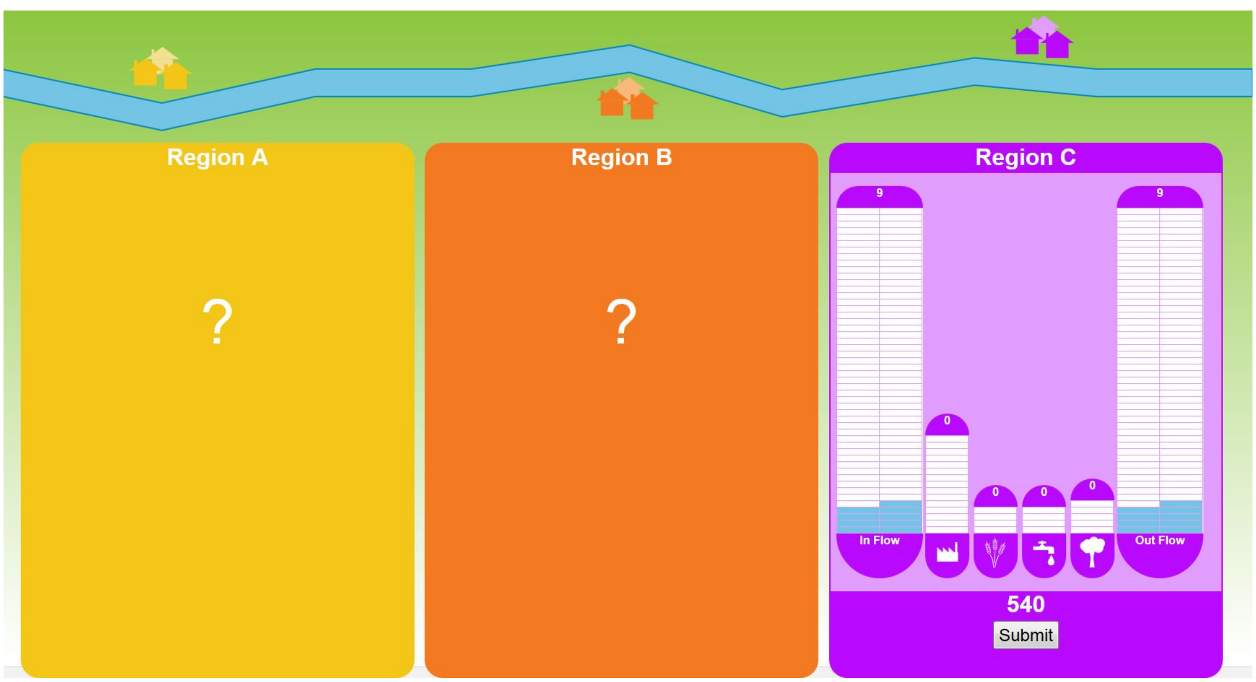


Fig. 6.6. Participants in Region C allocated their water units. When satisfied with their allocations after two minutes, participants in Region C were instructed to click Submit.

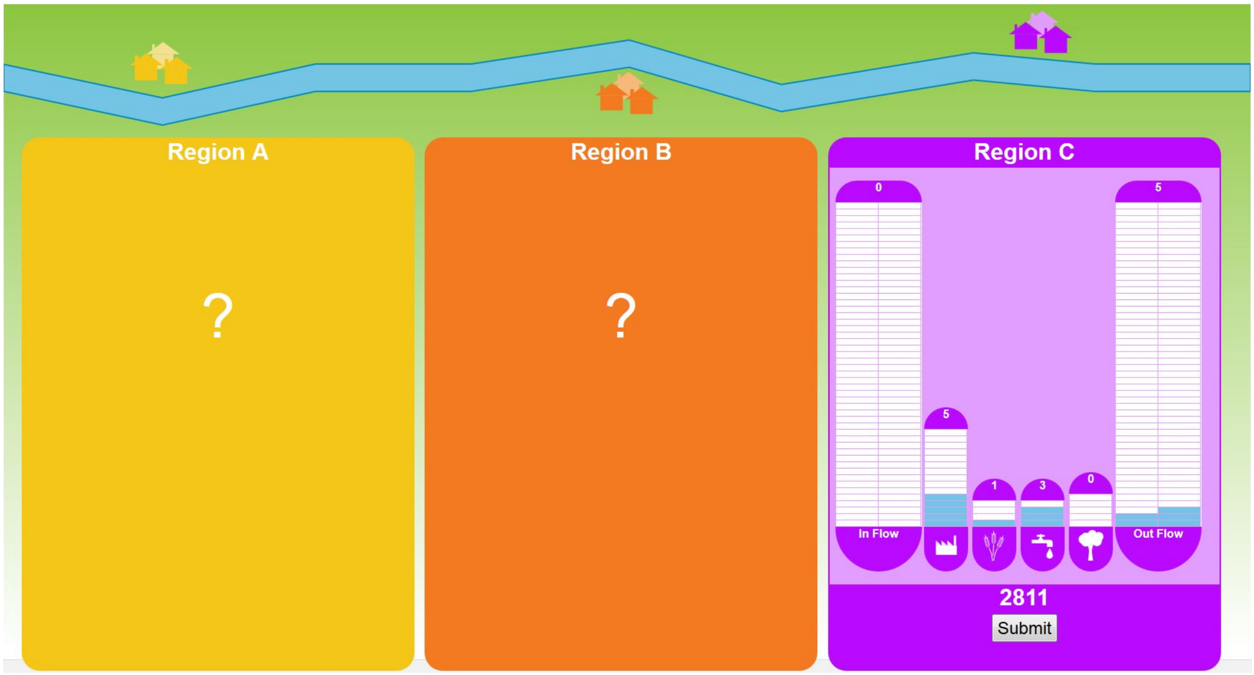


Fig. 6.7. After Region C clicked submit, participants were notified that they had completed the experiment.